



WELCOME

***VASCULAR PLANTS DIVERSITY AND ETHNOBOTANY
IN DUGDA DAWA DISTRICT OF BORANA ZONE,
OROMIA REGION, ETHIOPIA WITH EMPHASIS TO
TRADITIONAL MEDICINAL AND WILD EDIBLE
PLANTS***

PhD Dissertation

By

Mersha Ashagre Eshete

September, 2016

An outline of the presentation

CHAPTER ONE

1. INTRODUCTION

1.1. Background

1.2. Statement of the problem

1.3. Research questions, hypotheses and objectives

1.3.1. Research questions

1.3.2. Hypotheses

1.3.3. Objectives

1.4. Arrangement of the thesis

CHAPTER TWO

2. MATERIALS AND METHODS

2. 1. Description of the study site

2.2. Vegetation study of the district

2.3. Ethnobotanical study of medicinal plants and wild edible plants

2.4. Vegetation data analysis

2.5. Ethnobotanical data analysis

CHAPTER THREE

3. RESULTS

3.1. Biophysical factors

3.2. Plant diversity in Dugda Dawa District

3.3. Structure of the vegetation

3.4. Ethnobotanical studies in Dugda Dawa District

3.5. Medicinal plants used to treat only human ailments

3.6. Ethnoveterinary medicinal plants

3.7. Ethnobotanical study of medicinal plants used for both humans and livestock in Dugda Dawa District

3.8. Distribution of indigenous knowledge on medicinal plants among different social groups in the community of the study area

3.9. Ethnobotanical study of wild edible plants in Dugda
Dawa District

3.10. Other use diversities of all collected plant species from
the study area

CHAPTER FOUR

4.DISCUSSION,CONCLUSION,AND RECOMMENDATIONS

4.1. Discussion

4.2. Conclusion

4.3. Recommendations

CHAPTER ONE

1. INTRODUCTION

1.1. Background

- Plant diversity refers to the variety and variability of plant species.
- The vegetation cover of a given area has a definite structure and composition.
- Ethiopia is one of the states in the world with high level of biodiversity.
- Environmental degradation in Ethiopia is becoming the overriding cause for the loss of biodiversity.
- There is a significant lack of information on the ecology and diversity of some of the vegetation types in the country.

Cont.

- It is important to study and document the remaining vegetation resources to base conservation and sustainable utilization on scientific knowledge.
- Plant communities are defined as recognizable units of vegetation in a uniform environment.
- Recognition of plant communities helps in planning and implementing conservation strategies and sustainable utilization of plant resources.
- Examination of outlines of inhabitant's structures could provide valuable information about their regeneration and recruitment status.
- As different scholars define it, ethnobotany is the study of human uses of plants.

Cont.

- People have engaged in a relationship with medicinal, edible, and other useful local plants of the study area.
- Local knowledge built up across generations continues to play a fundamental role in supporting localized resource use practices.
- Indigenous people can contribute importantly to understand the processes of change which can be bounded to local events or global transformation processes.
- Pastoral and peasant communities that have maintained traditional modes of production have today become the major guardians of the world's crop and domestic animal diversity.

Cont.

On the other hand, overstocking and farmland expansion are the main causes of natural resources degradation.

- Despite these, studies on the floristic composition and ethnobotany of the woodland and dry afro-montane vegetation in Dugda Dawa District are lacking.
- Hence, the researcher is initiated to carry out research on plant diversity and ethnobotany of the district.

1.2. Statement of the problem

- The vegetation in Dugda Dawa District has been continuously used by the surrounding people because of :
 - Overgrazing and illegal timber harvesting (logging) for market;
 - Firewood collection and charcoal production;
 - Wood cutting for construction and other needs.
- Moreover, little is known about Dugda Dawa District's vegetation as there is no botanical study done before in the area.

Cont.

- Thus, the present study is initiated to generate basic scientific information on the diversity of plant species with emphasis to use and conservation of:
 - Traditional medicinal plants used for humans, livestock and for both humans and livestock;
 - Wild edible plants.

1. 3. Research questions, hypotheses and objectives

1.3.1. Research questions

- The investigation was targeted to address the following main questions:
 - What type of plant communities exist in the vegetation of Dugda Dawa District?
 - Are there species richness and diversity among different plant communities?
 - What seems the status and distribution of medicinal plants and wild edible plants across different plant communities?

Cont.

- What are the traditional medicinal plants used by people in Dugda Dawa District to treat human, livestock and/or both humans and livestock ailments?
- What are the wild edible plants used by the local people of the study area?
- Are there medicinal plants used to treat a particular disease with the agreement of local healers?

Cont.

- Are there common wild edible plants which are highly used during food shortage in the study area?
- Is there a trend to sell medicinal plants and wild edible plants in the market by the indigenous people?
- How do the local people use traditional medicinal plants to treat ailments? Have these plants other uses other than their medicinal role?

Cont.

- Are there factors affecting the transfer of traditional knowledge on medicinal plants and wild edible plants among different classes of the community members?
- What are the drivers of change in plant diversity?
- What seems the threats and conservation status of vegetation in the study area?

1.3.2. Hypotheses

- The possible suggestions could be:
 - Vegetation of the study area is with high species diversity and different plant communities;
 - Different plant species are used for traditional medicine and as wild food;
 - The local people are equipped with unique indigenous knowledge and culture in using wild plants for different purposes;
 - Different factors drive the depletion of plant diversity and little consideration is given to its conservation.

1.3.3. Objectives

General objective

- This research is aimed at documenting and analyzing the vascular plants diversity of Dugda Dawa District with emphasis to medicinal plants and wild edible plants.

Specific objectives

- Collect, make taxonomic determinations and prepare authentic list of plant species in the district;
- Identify plant community types of the vegetation of the study area;
- Compare species richness and diversity among different plant communities;
- Describe the population structure of selected tree species;

Cont.

- Identify medicinal plants used in the traditional healthcare system for humans, livestock and both humans and livestock ailments;
- Document information on medicinal plant parts used, modes of remedy preparation, routes of remedy administration and dosages;
- Identify and document plant species used as wild food by the local people of the study area;
- Investigate the utilization of medicinal and wild edible plant species in the study area;

Cont.

- Collect and record indigenous knowledge of the people on how the medicinal plants and wild edible plants are used;
- Identify major threats to and local conservation practices of plant species of the study area;
- Suggest who would add to the conservation and sustainable use of plant resources in the district; and
- Contribute to the efforts in voucher specimens' documentation at the National Herbarium (ETH) of AAU.

- Dugda Dawa District is located at 502 km south of Addis Ababa and 70 km from Yabelo town, the capital of Borana Zone.
- The altitude ranges from 800 to 2300 m.a.s.l. and it is dominantly characterized by rugged topography.
- Lies between latitudes $5^{\circ}53'$ N and $6^{\circ}27'$ N, and longitudes $39^{\circ}15'$ E and $40^{\circ}38'$ E.
- The total area of the District is 165,634.4 hectares.

CHAPTER TWO

2. MATERIALS AND METHODS

2. 1. Description of the study site

2.1.1. Location and topography

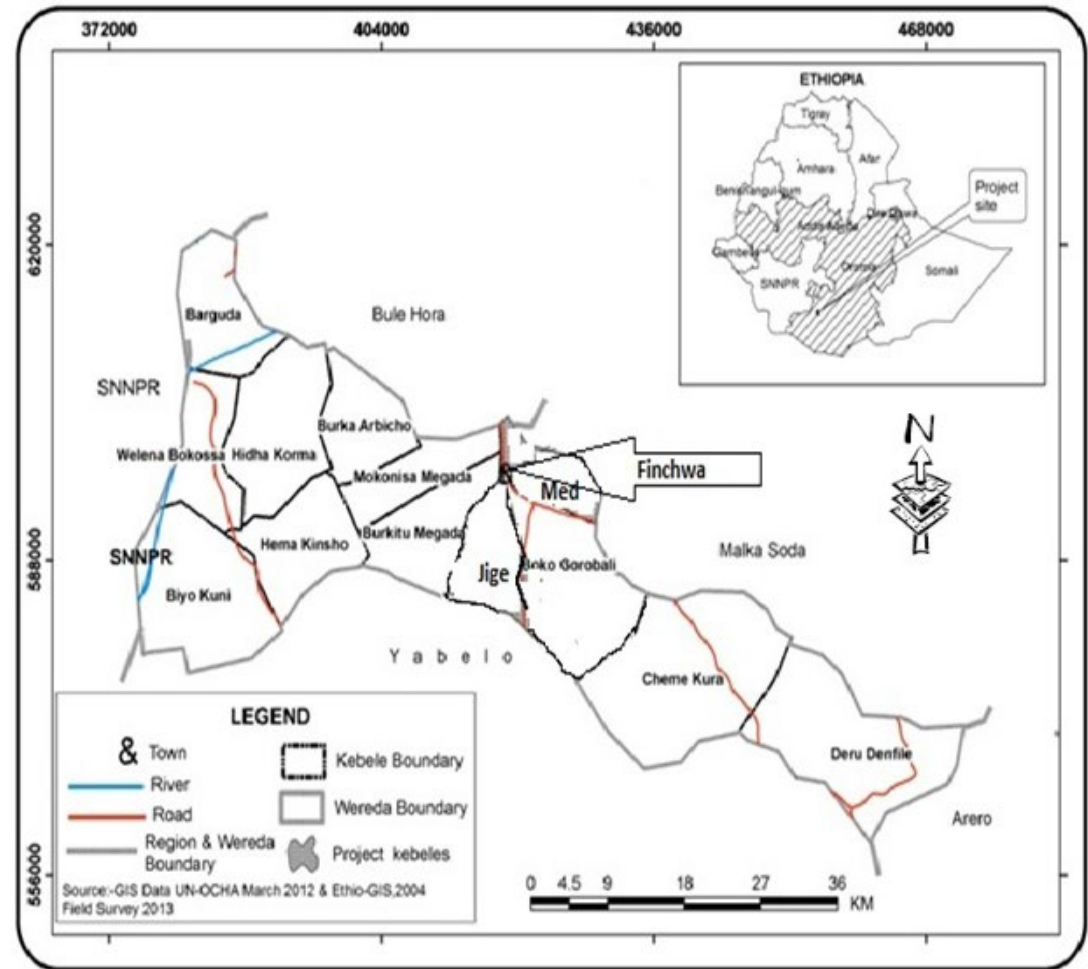


Figure 1. Map of Ethiopia showing Dugda Dawa District (the study area)

2. 1.2. Agro-ecology and climatic condition

- The district is divided into two agro-ecological zones:
 - The lowlands (from 800 -1500 m a.s.l) locally called “Gammoojjii” (41.8%).
 - Middle altitude (from 1501-2500 m a.s.l.) locally known as ‘Badadaree’ (58.2%).
 - Dugda Dawa District falls within the southern bimodal rainfall region of Ethiopia.

Cont.

- Receives high rainfall between March and half of June as well as relatively good amount from half of September to half of December.
- The dry season extends from half of December to February and to some extent from half of June to half of September.
- The highest mean annual average rainfall of the study area within 15 years was 111.6 mm recorded in April;

Cont.

- The lowest mean average was 3.3 mm recorded in July.
- The lowest mean average temperature over fifteen years was 12.7 c° recorded in December;
- The highest was 29.0 c° recorded in February.
- The mean annual rainfall of the study area was 486 mm and;
- The mean annual temperature was 20.5 c° .

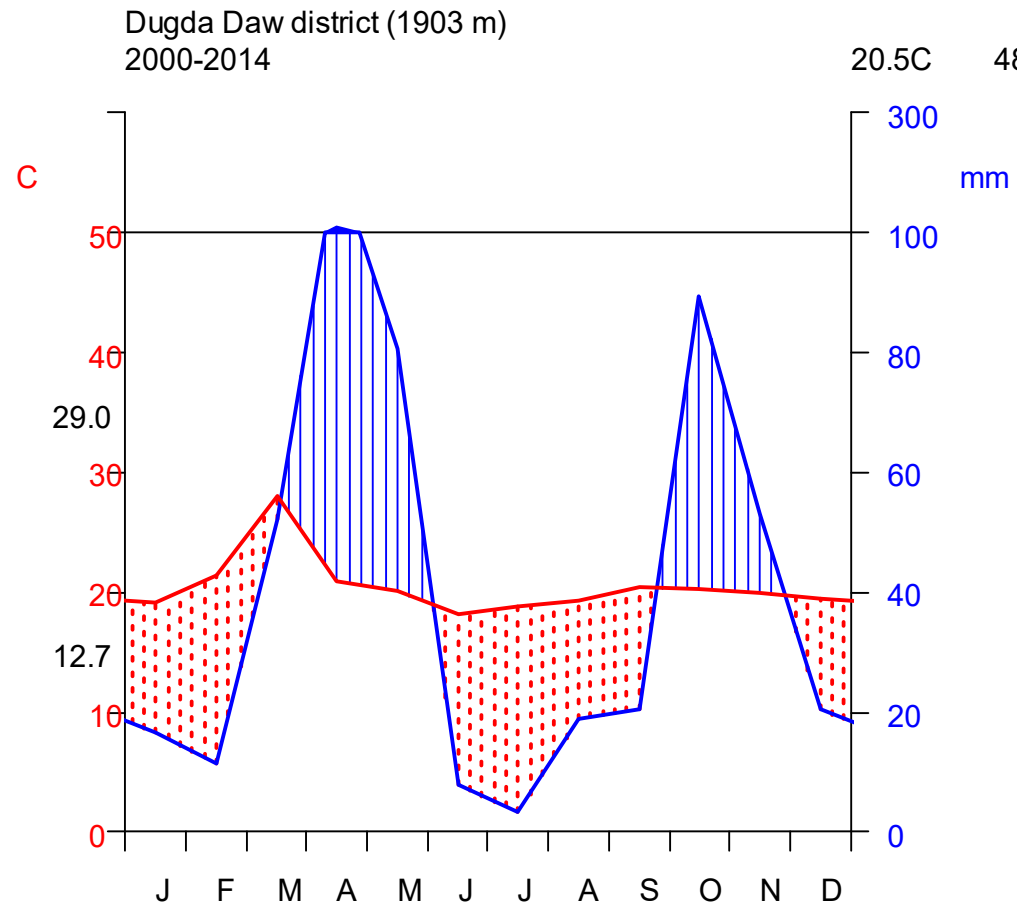


Figure 2. Climate diagram of Dugda Dawa District (From 2000 – 2014, 15 yrs).
(Source: National Meteorological Service Agency).

2.1.3. Human population

- The total population the district was 147,327 of which 75,114 were males and 72,213 were females.
- About 141,767 of the residents live in rural area of which 72,258 were males and 69,509 were females.
- Urban dwellers were about 5,560 out of which 2,856 were males and 2,704 are females (CSA, 2007).
- The population density (Number of people/Land area) is 0.9.

2.1.4. Land use and agriculture

Table 1: Land use pattern of Dugda Dawa District

No .	Land use Type	Area in hectare	%
1	Farming land	33,126.8	20.0
2	Pasture land (Grazing land)	65,910.2	39.8
3	Degraded /Barren area/Non - usable land	8545.4	5.2
4	Forest land	29,815	18.0
5	Shrub/Bush land	26,091	15.7
6	Settlement and Home garden	2146	1.3
	Total	165,634.4	100.0

2.1.5. Vegetation of the study area

- The study area falls in the Subtropical Arid climate with deserts, Walter (1983) and in the Somalia - Masai Regional Centre of endemism, White (1983) .

- The vegetation of the study area is composed of:
 - *Acacia - Commiphora* Woodland and Bushland;

 - *Combretum-Terminalia* Woodland and;

 - *Dry Evergreen Afro-montane Forest* and *Grassland Complex*, Friis et al., (2011.

Cont.

- *Acacia-Commiphora* Woodland and Bushland vegetation type is characterized by:
 - Drought resistant trees and shrubs;
 - Occurring between 800 and 1800 m (include species of *Acacia*, *Balanites*, *Commiphora*).
- *Combretum-Terminalia* woodland vegetation type is characterised by:
 - Small to middle-sized trees with fairly large deciduous leaves;
 - Occurring between 800 and 1800 m and include species of *Terminalia*, *Combretum*, and *Lannea* in this area.

Cont.

- Dry Evergreen Afro-montane Forest (small part of the vegetation of the district) type represents shrubs and small to large-sized trees.
- This forest has canopies usually dominated by *Podocarpus falcatus* with *Celtis africana* and *Croton macrostachyus* as co-dominant, followed by *Olea europaea* subsp. *cuspidata*, etc.
- Over grazing, extraction of fuel wood and charcoal as well as illegal timber production are factors affecting these vegetation.

2.1.6. Human health condition in the district

- Of the 147,327 people 81,030 are assisted by modern health services which covers only 55% of the population.
- There are three governmental health centers and 16 health posts in the district.
- Concerning human health professionals in the district, there are:
 - ✓ five health officers,
 - ✓ two nurses,
 - ✓ 40 clinical nurses,
 - ✓ two laboratory technicians,
 - ✓ one sanitarian,
 - ✓ eight midwives,
 - ✓ one pharmacist,
 - ✓ 54 health extension workers and;
 - ✓ 10 supportive staffs.
- The five common health problems in the district are *acute respiratory tract infection, pneumonia, typhoid, internal parasitosis, and malaria.*

2.1.7. Livestock health condition in the district

- The presence of 785,538 livestock population were reported in the District of which:
 - ✓ 338,000 cattle;
 - ✓ 238,662 goats;
 - ✓ 64,123 sheep;
 - ✓ 27,138 camels;
 - ✓ 21,093 donkeys;
 - ✓ 1,589 mules;
 - ✓ 187 horses, and 94,746 poultry.

- Modern Veterinary health care coverage of the district is about 40 %.
- There is one level C and 11 level D livestock clinics.
- Concerning livestock health professionals there are 6 animal health assistances and 2 technicians.

Cont.

- Due to poor access to modern medical services and low-income level of most households, the local people use local traditional healers and traditional ethnoveterinary services to treat their livestock ailments.
- The major livestock diseases reported in the study area were:
 - ✓ contagious bovine pleuro - pneumonia (CBPP);
 - ✓ bovine pasteurellosis;
 - ✓ blackleg (abbaa gorbaa);
 - ✓ tick infection;
 - ✓ trypanosomiasis (gandii);
 - ✓ babesiosis (hadhootu);
 - ✓ anthrax (abbaa sangaa);

Cont.

- ✓ foot and mouth disease or FMD (maansaa);
- ✓ skin and lamp disease (LSD) or bagaa in Oromo language;
- ✓ internal and external parasites (maxantuu qaama keessa fi qaama alaa);
- ✓ mastietis (naqarsaa muchaa);
- ✓ blotting and constipation;
- ✓ nervous system problems;
- ✓ viral diseases called CCPP - Contagious caprine pleuro - pneumonia (lung disease) and ;
- ✓ PPR which seems render pest disease.

2.1.8. Food security condition in the District

- Very poor households fall in food shortage at certain times of the year, when irregular environmental conditions occur in the study area.
- For these families, the natural vegetation provides an important safety net, and it is in these critical times that the significance of forest foods is utmost.
- Fruits, roots, leaves, seeds, barks, flowers and gums of a variety of forest and woodland plants are consumed at different times in the study area.

Cont.

- Many species of trees found in forest as well as shrubs and grasses are used in several ways to the general food and nutritional security of livestock.
- Tree fodder and browse may consist of leaves, small twigs, seeds, pods and fruits, all of which support other foods and which can be a crucial component of livestock diets during the dry season.

2.2. Vegetation study of the district

2.2.1. Reconnaissance survey

- Was from August 12- 27, 2013 and the necessary fieldwork materials were made ready.

2.2.2. Sampling design

- **Preferential sampling** following (Mueller - Dombois and Ellenberg 1974) was used for this study;
- Quadrats (plots) were placed on sites that were perceived as typical of given conditions indicated by homogeneity.
- This sampling method was used for this study due to three reasons:

Cont.

- ✓ It enables to know the plant diversity since the plots can be laid at any place in the 13 kebeles (the smallest administrative units) of the District;
- ✓ Is a good option to collect both ecological and ethnobotanical data simultaneously;
- ✓ Since there is no single dense forest in the District systematic sampling with line transect could not be used.

- The apparent **advantage** of preferential sampling is:
 - ✓ It tracks and samples nearly the full range of floristic dissimilarity in vegetation of the study area, as well as the rare types.
- The vital **reservation** against preferential sampling is: t
 - ✓ The arrangement of the sample is to an unknown degree influenced by the subjective decisions of the researcher.
- A total of 60 quadrats (20 m x 20 m) were laid for vegetation data collection.

Cont.

- In addition, five 1 m x 1 m sub plots, one at each corner, and one at the center of the main plot were also laid to sample herbaceous plants.

2.2.3. Vegetation data collection

- Data collection was conducted five times:
 - from November 01 to December 30, 2013;
 - June 02 to July 30, 2014;
 - November 01 to December 30, 2014;
 - June 02 to July 30, 2015 and;
 - November 01 to December 30, 2015.

Cont.

- A complete list of trees, shrubs, lianas, herbs and climbing herbs including vascular epiphytes and medicinal avascular species was made from each preferentially selected plot;
- Species occurring within 10 m distance from the plots boundaries were also recorded as present for floristic composition;
- In each plot structural attributes such as diameter and height were recorded for all woody plants;
- Measure of diameter was taken for all individual trees and shrubs having DBH (Diameter at Breast Height) greater than 2.5 cm using a diameter tape;

Cont.

- If the tree branched at breast height or below, the diameter was measured separately for the branches and averaged;
- Trees and shrubs species with DBH less than 2.5 cm were counted;
- Height was measured for each tree and shrub with DBH greater than 2.5 cm using calibrated stick and for big trees estimation was used;
- Where topographic features made difficult to measure height of trees and shrubs, it was estimated visually.

➤ The presence-absence and cover abundance data were later converted to cover abundance values using the modified 1-9 Braun-Blanquet scale (as in van der Maarel, 1979) as follows:

- 1: Rare, generally one individual;
- 2: Occasional, with less than 5% cover of the total;
- 3: Abundant, with less than 5% cover of the total;
- 4: Very abundant, with less than 5% cover of the total;
- 5: 5-12% cover of the total area;
- 6: 12-25% cover of the total area;
- 7: 25-50% cover of the total area;
- 8: 50-75% cover of the total area and;
- 9: 75-100% covers of the total area.

Cont.

- Investigation of the seedling and sapling density and regeneration of some selected species has been carried out within the same quadrat;
- In each of these quadrats, the number of all **seedlings** that are less than 1 m in height were recorded;
- Individuals reaching 1 m and above with DBH less than 2.5 cm were considered as **sapling** and counted.

Cont.

- Environmental variables such as altitudes and geographical coordinates were also measured for each plot using GPS 60 (Geographical Position System);
- Standard procedure was followed in pressing the specimens, which were then brought to the National Herbarium (ETH), Addis Ababa University;

Cont.

- Specimens were allowed to dry, deep-frozen and determinations made using taxonomic explanations and descriptions given in the relevant volumes of the Flora of Ethiopia and Eritrea.
- Further refining of determinations was made by visual comparison with authenticated herbarium specimens and finally checking the accuracy by a senior plant taxonomist.
- The plant specimens with labels were finally deposited at the ETH and the resulting data of the study presented in tables, graphs, and percentages.

2.3. Ethnobotanical study of medicinal plants and wild edible plants

2.3.1. Informants size determination and selection

- Amount of informants for medicinal plants study was determined by using Cochran's (1977) formula as indicated by Bartlett, Kotrlik, and Higgins (2001) with reference to size of households from all pastoralist kebeles of the District as follows:

$$n = \frac{N}{1 + N(e)^2}$$

Where,

n = sample size for the research; N= total number of households in all the 13 kebeles.

e= maximum variability or margin of error 5% (.05); 1= the probability of the event occurring.

Cont.

- The total number of households was 18,709. Hence, the informant size becomes;

$$= \frac{18,709}{1+18,709(0.05)^2} = \frac{18,709}{47.7725} = \underline{\underline{392}} \text{ informants}$$

- *Informants from each kebele = Number of households of the kebele X Total number of informants/Total number of households.*
- For example, the informant size of Berguda kebele with a total household of 797 was 17, i.e. $(797 \times 392/18,709 = 17)$.

Cont.

- Three to five key informants were taken purposefully from each kebele based on the size of the households (a total of 50 key informants).
- The key informants include healers, herbalists, elders and practitioners based on their knowledge as recommended by the local people.
- The remaining 342 general informants were taken by random sampling method to include some important informants from different age groups, sex and occupation.

Cont.

- The selected informants were interviewed using semi-structured interview on the identification, management and use of the traditional medicinal plants;
- A total of 130 informants from those selected for medicinal plants study were taken for wild edible plants study
- Of which 26 key informants, at least two key informants from each Kebele, were selected using purposive sampling technique for those who are knowledgeable about wild edible plants;

Cont.

- The remaining 104 informants, eight informants from each Kebele, were selected randomly from the all kebeles;
- The selected informants in the sample site were interviewed using semi-structured interview on the management and use of wild edible plants

2.3.2. Ethical considerations and interviewing protocol

- Formal written permission was obtained from the district administration;
- To create a positive interaction and develop a good understanding between informants and the researcher the objectives of the study was explained briefly and clearly;
- The interview was administered after the informants permitted to cooperate with the researcher in providing the required information;

Cont.

- Therefore, ethnobotanical data were collected based on a comprehensive participation, good interactions and the willingness of informants;
- Ethnobotanical data on the traditionally used medicinal plants and wild edible plants as well as the associated indigenous knowledge was collected using semi-structured interview;
- Semi-structured interview questionnaires conducted after translated into Oromo language where the informants were most comfortable and during the time they wanted or chose.

Cont.

- For ethical reasons, ethnobotanical data were collected in the presence of local administrators and with the permission of each informant for the publication of the research;
- Good specimens (those bearing flowers and/or fruits) of all medicinal plants and wild edible plants identified by the informants were collected as voucher specimens.

2.3.5. Secondary data collection

➤ Secondary data such as:

- 15 years climate data from National Meteorology Service Agency;
- Population data from Central Statistical Agency;
- Health problem data from the local modern health centers and;
- Veterinary problems data from local modern veterinary clinics were collected by accepting written document and interviewing the responsible officers.

2.3.6. Field observation and group discussion

- Field observation and group discussion was made about:
 - the status of the vegetation;
 - the acceptance of the medicinal plants by the societies and;
 - usage of wild edible plants.
- Field observations were performed with the help of local guides and interviewed informants in the study area.
- A brief group discussion was made three times with the local people (5 to 7 informants) at each site about:
 - the status of the vegetation associated with their ethnomedicinal knowledge;

Cont.

- status of threats and conservation attempt;
 - effect of climate change;
 - acceptance of traditional healers and full notes were recorded.
- During the discussion the informants were free to state about the traditional medicinal plants and their knowledge without being interfered.

2.3.7. Market survey

- Rich sources of ethnobotanical information, since market is the site at which medicinal, ornamental, wild edible and other useful plants are sold.
- Was done in the biggest market of the district (Finchuwa market).

2.4. Vegetation data analysis

2.4.1. Multivariate analysis of vegetation data

- A hierarchical cluster analysis was done using PC-ORD for windows version 5.0 (McCune and Mefford, 1999) to categorize the vegetation into plant community types **based on cover data of the species** in each quadrat;
- The Relative Euclidean Distance (RED) measures using Ward's method were used in this study;
- The data matrix contained 60 plots and 294 species collected from the sample plots (Figure 3);

Cont.

- The Euclidean Distance was used since it eliminates the variations in total cover among sample units;
- The Ward's method was used because it minimizes the total within group mean of squares or residual sum of squares (van Tongeren, 1995; McCune and Grace, 2002);
- The groups were further tested for the hypothesis of no variation between the groups using the multiresponse permutation procedure (MRPP);
- Dufren and Legendre's (1997) method of calculating species indicator values was used to sense the values of different species;

Cont.

- Indicator species are described as the most characteristic species of each group found mostly in a single group of the typology and present in most of the sites belonging to that group.
- Indicator values are measures of the fidelity of the occurrence of a species in a particular group (McCune and Mefford, 1999) and its value ranges from zero (no indication) to 100 (perfect indication).

Cont.

- The clusters were chosen as plant community types and given names after one or two dominant or characteristic species;
- A species is regarded as an indicator of the group when its indicator value is significantly higher at $P < 0.05$.

2.4.2. Diversity and similarity indices

- Shannon-Wiener diversity index, species richness, and Shannon's evenness were computed to describe species diversity of the plant community types in the vegetation;

- **Shannon-Wiener diversity index** was calculated as follows:

$$H' = - \sum_{i=1}^s P_i \ln P_i$$

Where;

H' = Shannon diversity index,

S = the number of species,

P_i = the proportion of individuals or the abundance of the i th species expressed as a proportion of total cover and

\ln = logbase_n

Evenness (Equitability) $J = H' / H'_{\max}$ where;

J = Evenness,

H' = Shannon-Wiener diversity index and

$H'_{\max} = \ln s$ where s is the number of species.

- The higher the value of J, the more even the species is in their distribution within the community or the quadrats.
- Similarly, the higher the value of H', the more diverse the community or the quadrat are.
- **Sorensen's similarity index** was used to determine the pattern of species turnover among successive communities and to compare the vegetation with other similar vegetation in the country.
- It is described using the following formula (Kent and Coker, 1992).

$$S_s = 2a / (2a + b + c) \text{ Where:}$$

S_s = Sorensen's similarity coefficient

a = Number of species common to both samples;

b = Number of species in sample 1;

c = Number of species in sample 2

Comparing communities: Jaccard's index

- *Jaccard's index* was used in comparing biodiversity levels across sites as follows:

$$J = \frac{S_c}{S_a + S_b + S_c}$$

Where;

- ✓ S_a and S_b are the numbers of species unique to samples a and b, respectively,
- ✓ S_c is the number of species common to the two samples.
- Jaccard's index of similarity is very straightforward since it is simply the fraction of species shared between the samples.
- It utilizes the richness component of diversity.

2.4.3. Structural analysis

➤ The structure of the vegetation was explained using frequency distributions of DBH, height and Importance Value Index (IVI).

➤ Tree or shrub density and basal area values were computed on hectare basis.

➤ There is direct relationship between DBH and basal area.

Basal area = $(\text{DBH}/2)^2 \times 3.14$ Or $\text{BA} = \pi d^2/4$, where, $\pi = 3.14$ and $d = \text{DBH (m)}$.

Dominance = $\frac{\text{Mean basal area}}{\text{Tree}} \times \text{the number of trees of a species}$

Relative dominance = $\frac{\text{Dominance of a species}}{\text{Dominance of all species (DBH} > 2.5\text{cm)}} \times 100$

- **Density:** is defined as the number of plants of a certain species per unit area.
- It is closely related to abundance but more useful in estimating the importance of a species.

$$\text{Relative density} = \frac{\text{The number of all individuals of a species}}{\text{The total number of all individuals (DBH > 2.5 cm)}} \times 100$$

$$\text{Frequency} = \frac{\text{Number of plots in which a species occur}}{\text{Total number of plots}} \times 100$$

- The frequencies of the tree species in all the 60 plots were computed.
- The higher the frequency, the more important the plant is in the community.

$$\text{Relative frequency} = \frac{\text{Frequency of a species}}{\text{Total frequency of all species}} \times 100$$

- Even though a high frequency value means that the plant is widely distributed through the study area, the same is not necessarily true for a high abundance value.
- Abundance is not always an indicator of the importance of a plant in a community.

Importance Value Index (IVI) - joins data for three parameters (relative frequency, relative density, and relative abundance) and was computed for dominant species to determine their dominance, as follows (Kent and Coker, 1992):

$$IVI = \textit{Relative Density} + \textit{Relative Dominance} + \textit{Relative Frequency},$$

- Is useful to compare the ecological significance of species (Lamprecht, 1989).

2.5. Ethnobotanical data analysis

- Different statistical applications were used to analyze ethnobotanical data from calculating a simple index to complex computational methods of multivariate analysis such as categorization by using SPSS or R - Software.

2.5.1. Ranking and comparison

2.5.1.1. *Preference ranking*

- Rank ordering of medicinal/wild edible plants is used to determine their order of cultural importance across a community.
- Preference ranking was computed by taking:
 - 10 key informants to assess the degree of effectiveness on those medicinal plants used to treat a particular disease and;
 - Eight key informants to assess the degree of importance on those wild edible plants highly cited by the informants used as food at a particular time (Martin, 1995).

2.5.1.2. *Direct matrix ranking*

- Is a more multifaceted version of preference ranking.
- Here informants order medicinal/wild edible plants by considering several attributes one at a time.
- Ranking of threats on 10 medicinal/wild edible plants that were reported by most of the informants in the study area was conducted using ten key informants as described by Martin (1995) and Alexiades (1996).
- This information was used to determine:
 - the highest threats to traditional medicinal/wild edible plants in the study area and;
 - help to suggest appropriate conservation measures as considered.

2.5.1.3. *Informant consensus factor*

- ICF was considered for each group of ailments to identify the harmony's of the informants on the reported cures for the group of ailments of the plant.

$$ICF = \frac{n_{ur} - n_t}{n_{ur} - 1} \text{ where;}$$

n_{ur} = number of use citations in each group ,

n_t = minus the number of species used (Heinrich *et al.*, 1998).

- Medicinal plants that were effective in treating groups of ailments had a higher informant consensus factor value.

2.5.1.4. *Fidelity level (FL)*

- FL computes the significance of a species for a given purpose.
- Most commonly used medicinal plants have high fidelity level value.

$$FL = N_p / N \text{ where;}$$

N_p = the number of informants who independently cited the importance of a species to treat a particular disease,

N = total number of informants who reported the plant to treat any given disease.

$$FL\% = (N_p / N) \times 100 \text{ (Alexiades, 1996).}$$

2.5.1.5. *Use value*

- Is a quantitative method that demonstrates the relative importance of species known locally, which reflects the importance of each species to informants i. e.

$$UV_{is} = \sum U_{is} / n_{is}$$

Where UV_{is} = use value of a species s for informant i ,

U_{is} = the number of uses mentioned in each event by informant i ,
and

n_{is} = the number of events for species s with informant i

- **2.5.1.6. Determination of endemic plant species and their extent of threat in Dugda Dawa District vegetation**

- Dugda Dawa Districts' endemic plant species and the level of their threat was determined based on the reports of Ensermu Kelbessa *et al.* (1992) and Vivero *et al.* (2005).
- This helped to identify which plant species should be given priority in the future conservation activities.

CHAPTER THREE

3. RESULTS

3.2. Plant diversity in Dugda Dawa District

3.2.1. Plant species composition of the vegetation

- Samples were collected from all kebeles of the District.
- A total of 344 plant species belonging to:
 - 227 genera and;
 - 81 families were recorded and identified.
- Out of these, 73 species were trees, 118 species were shrubs, 31 species were lianas, 107 species were herbs, 14 species were climbing herbs and one species was fern.

Cont.

- Fabaceae was the most dominant with 41 species (11.9%) and followed by Asteraceae with 28 species (8.1%).
- Of all the species collected, 93.8% were dicots, 4.7% were monocots, and 1.5% was fern and mosses.
- The large percentage of dicots could be due to the suitability of the study area for these groups of plants.
- Analysis of the habit or growth forms of species recorded gave the highest proportion (32.4%) was contributed by shrubs.

3.2.2. Endemism

- Based on the classification of Vegetation of the Earth, vegetation of Dugda Dawa District lies in the zonobiome of the humido - arid tropical summer rain region with deciduous forests (Walter,1983);
- With reference to the classification of the Vegetation of Africa into phytochoria, it is found in the Somalia - Masai Regional Centre of Endemism (White,1983);
- Because this regional centre of endemism includes eastern and southern parts of Ethiopia except the mountains.

- Hence, 13 (3.8%) endemic plant species, some of which are in the IUCN Red Data List, were identified in Dugda Dawa District, Ensermu Kelbessa *et al.*, (1992) and Vivero *et al.*, (2005) - Table 4.

No.	Scientific Name	Family	Status
1	<i>Acanthus sennii</i>	Acanthaceae	NT
2	<i>Bothriocline schimperi</i>	Asteraceae	LC
3	<i>Cussonia ostinii</i>	Araliaceae	NT
4	<i>Echinops ellenbeckii</i>	Asteraceae	EN
5	<i>Hibiscus boranensis</i>	Malvaceae	VU
6	<i>Kirkia burgeri</i>	Simaroubaceae	VU
7	<i>Lantana kisi</i>	Verbenaceae	EN
8	<i>Leucas abyssinica</i>	Lamiaceae	LC
9	<i>Lippia adoensis</i>	Verbenaceae	LC
10	<i>Millettia ferruginea</i>	Fabaceae	LC
11	<i>Rhus glutinosa</i>	Anacardiaceae	VU
12	<i>Thunbergia ruspolii</i>	Acanthaceae	LC
13	<i>Vepris dainellii</i>	Rutaceae	LC

3.2.3. Commercially important tree species

- Dugda Dawa District vegetation contained 8 (33.3%) out of 24 major commercial indigenous tree species reported by EFAP (1994) and Million Bekele and Leykun Berhanu (2001).
- These tree species include *Albizia schimperiana*, *Cordia africana*, *Juniperus procera*, *Celtis africana*, *Croton macrostachyus*, *Ekebergia capensis*, *Syzygium guineense*, and *Warburgia ugandensis*.

3.2.4. Vegetation classification

- Four plant communities were seen from the hierarchical cluster analysis (Figure 4).

Cont.

- As it was calculated with MRPP in the PC -ORD, the test statistics T value for the four groups was **-6.78** ($P < 0.0000015$), highly significant and;
- The test statistics T describes the separation between the groups and the more negative T value, the stronger the separation.
- The agreement statistics A was 0.039.
- In community ecology, values of A (agreement) are commonly below 0.1 which describes within group homogeneity (McCune and Mefford, 1999).
- The probability value ($P^* < 0.05$) refers to Monte Carlo tests.
- From this result, therefore, the hypothesis “**there are different plant community types**” can be accepted.

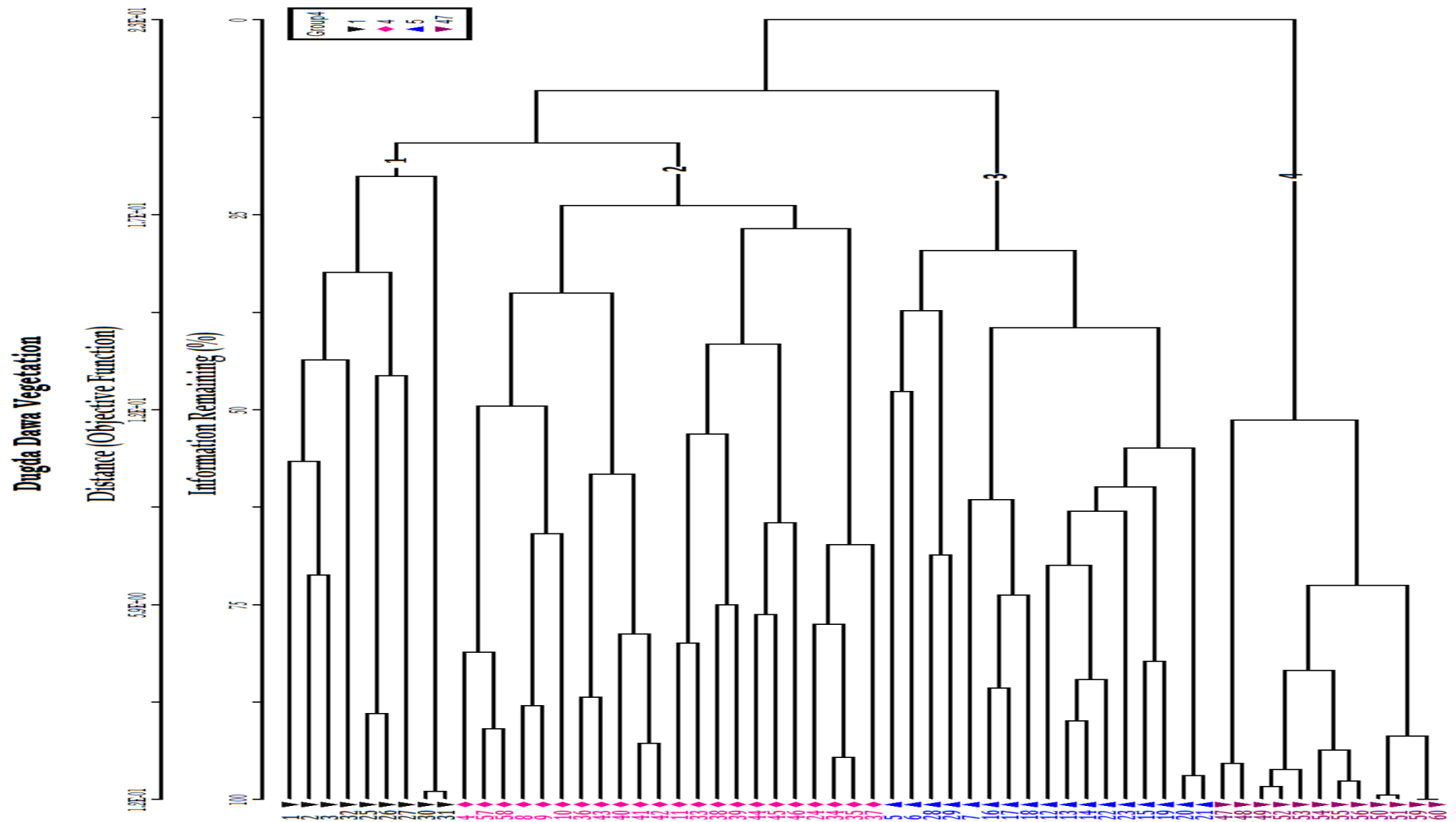


Figure 4. Dendrogram of the vegetation data obtained from hierarchical cluster analysis of Dugda Dawa District vegetation using Ward's method and Euclidean distance. The level of grouping was based on about 20 % Information remaining. (1 = Community type 1, 2 = Community type 2, 3 = Community type 3 and 4 = Community type 4).

Cont.

- Dominance was used to describe both the community and individual species;
- Hence, community names were given after two tree or shrub species that had higher cover value.
- Species restricted to one or a few habitat types **potentially represent better indicators** than those habitat generalists owing to their greater susceptibility to local or regional extinction following environmental change.

Cont.

- Thus the identified groups are more or less coinciding with the natural associations that anyone can observe while visiting the study area.
- The four plant communities identified were:
 - *Nuxia oppositifolia* - *Calpurnia aurea* (Community type 1);
 - *Faurea speciosa* - *Terminalia schimperiana* (Community type 2);
 - *Boscia mossambicensis* - *Lannea schimperi* (Community type 3);
 - *Margaritaria discoidea* - *Maytenus undata* (Community type 4).

Table 5. Community types and their member plots in the vegetation of Dugda Dawa District

Community type	Plots
1	1, 2, 3, 32, 25, 26, 27, 30, 31 = 9
2	4, 57, 58, 8, 9, 10, 36, 43, 40, 41, 42, 11, 33, 38, 39, 44, 45, 46, 24, 34, 35, 37 = 22
3	5, 6, 28, 29, 7, 16, 17, 18, 12, 13, 14, 22, 23, 15, 19, 20, 21 = 17
4	47, 48, 49, 52, 53, 54, 55, 56, 50, 51, 59, 60 = 12

Community 1. *Nuxia oppositifolia* - *Calpurnia aurea* community type

- Was composed of 9 quadrats and 100 species.
- Altitudinal ranges was 1603 and 2283 m a.s.l.
- Had nineteen indicator species (*Nuxia oppositifolia*, *Sida collina*, *Oplismenus hirtellus*, *Calpurnia aurea*, etc.)

Community 2. *Faurea speciosa* - *Terminalia schimperiana* community type

- Was represented by 22 quadrats and 130 species.
- Had five indicator species (*Faurea speciosa*, *Terminalia schimperiana*, *Rhoicissus revoilii*, *Fuerstia africana* and *Dodonea angustifolia*).
- Altitudinal range of this community was from 1637- 1968 m a.s.l.

Community 3. *Boscia mossambicensis* - *Lannea schimperi* community type

- Dominated by the woody climbers such as *Capparis fascicularis*, *Capparis tomentosa*, *Jasminum eminii* and *Jasminum grandiflorum*.
- Lies along the altitudinal range of 1273 to 1660 m .a.s.l.
- Seventeen quadrats and 164 species were encountered.

Community 4. *Margaritaria discoidea* - *Maytenus undata* community type

- Was situated at altitudinal ranges from 1915 to 1975 m a.s.l.
- Was comprised of 12 quadrats and 65 species.
- *Euphorbia depauperata*, *Solanum incanum*, *Margaritaria discoidea*, *Dioscorea schimperiana*, *Maytenus undata*, *Ekebergia capensis* were some of indicator species.

4.2.5. Similarity among plant communities

- Both Sorenson's similarity coefficient and Jaccard's index of similarity were used to determine the similarities among plant communities (Table 7 and 8).

Table 7. Sorensen similarity coefficient among community types

Communities	1	2	3	4
1				
2	0.31			
3	0.29	0.36		
4	0.28	0.31	0.18	

Table 8. Jaccard's index of similarity among community types

Communities	1	2	3	4
1				
2	0.29			
3	0.26	0.39		
4	0.25	0.29	0.12	

➤ In both cases communities 2 and 3 had the highest similarity ratio.

Cont.

- The least similarity was exhibited by communities 1 and 4.
- This could be associated with anthropogenic influences, variation in altitude, slope, aspect, soil type and other environmental factors.

4.2.6. Species diversity, evenness, and richness of the plant communities

Table 9. Shanon Wiener Diversity Index for the communities

Community	Average Altitude (m a.s.l.)	Species richness	Diversity Index (H')	H' max (lns)	Evenness (H'/H' max)
1	1872	100	4.37	6.87	0.64
2	1808	130	4.35	7.91	0.55
3	1560	164	4.69	7.94	0.59
4	1947	65	3.63	7.19	0.51

- Both species richness and diversity was observed in community three .
- Community one was seen with its evenly distributed species.
- Community type 2 was with intermediate richness and diversity

4.3. Structure of the vegetation

4.3.1. Tree and shrub density

- About 54% shrubs and trees have DBH 3 – 10 cm and 15% of these growth forms have DBH greater than 20 cm with in one hectare.

Table 10. **Number of individuals** under diff.DBH classes

DBH (cm)	No. of individuals/ha	%
3 - 10	554.31	53.9
11 - 20	316.36	30.8
>20	157.25	15.3
Total	1027.92	100

4.3.2. Size (height and DBH) class distributions

- More than 50% of the individuals had **height** 5 - 14 m (Height classes 1 and 2).
- About 27% of trees reached height 10 - 14 m and indicating slight reduction of smaller individuals.

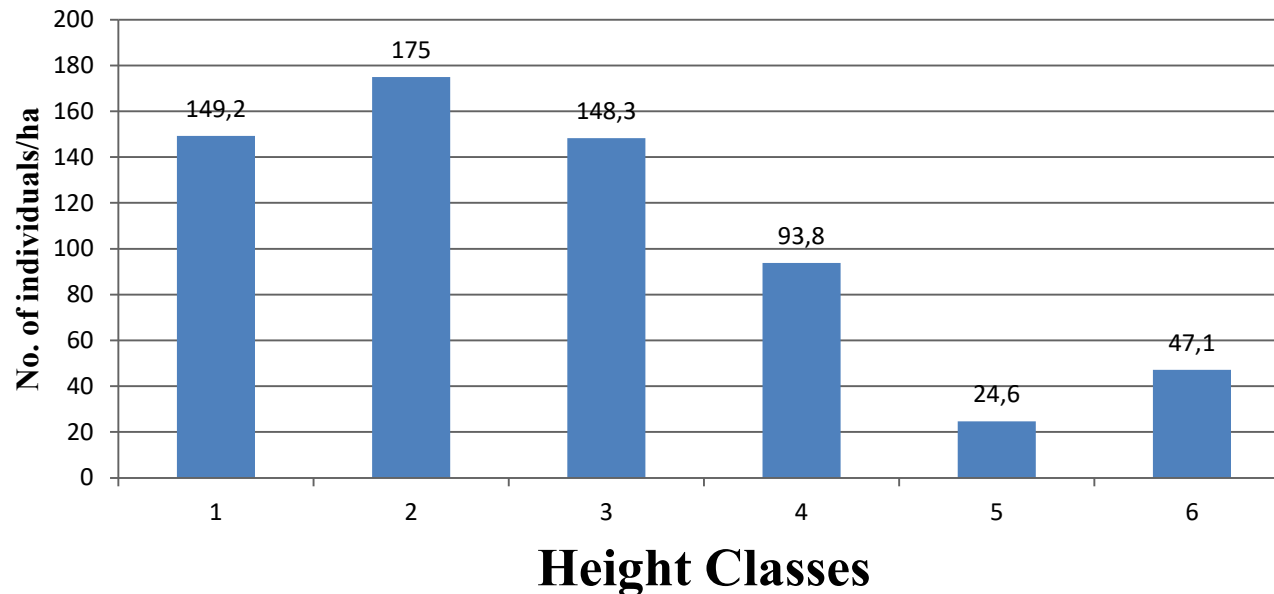


Figure 9. Height classes versus relative density/ha of Dugda Dawa District vegetation.

Legend: 1 = 5 - 9 m, 2 = 10 - 14 m, 3 = 15 - 19 m, 4 = 20 - 24 m, 5 = 25 - 29 m and 6 >29 m

- DBH class (the diameter at breast height) was decreasing in the 5th, 7th and 8th DBH classes (23 - 27 cm, 33 - 37 cm and 38 - 42 cm) and increasing in the 1st and 2nd DBH classes (3 - 7 cm and 8 - 12 cm).

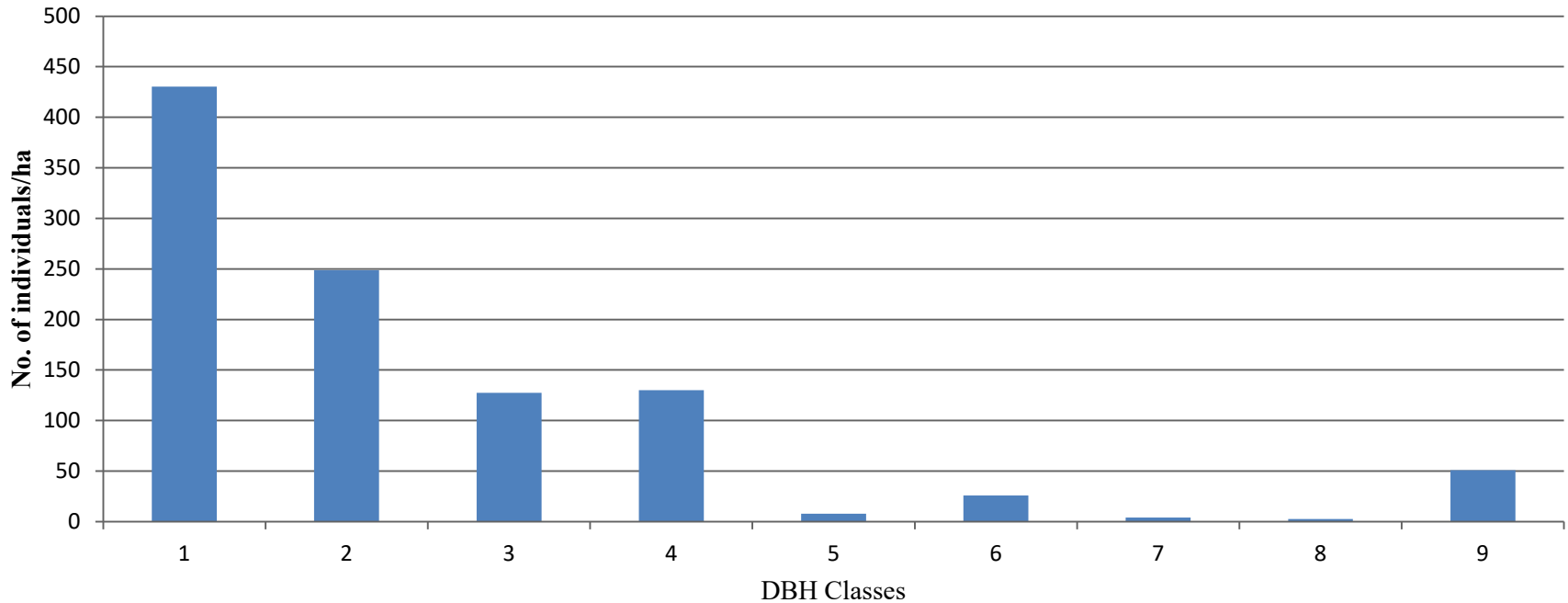


Figure 10. DBH class versus the number of individuals/ha

Legend: DBH class 1 = 3 - 7 cm, 2 = 8 - 12 cm, 3 = 13 - 17 cm, 4 = 18 - 22 cm, 5 = 23 - 27 cm, 6 = 28 - 32 cm, 7 = 33 - 37 cm, 8 = 38 - 42 cm, 9 = > 42 cm.

4. 3. 3. Basal area

- The total basal area of representative tree species in Dugda Dawa District vegetation as calculated from DBH data was found to be 90.4 m²/ha (constitute 0.90% of the total ground area).
- *Podocarpus falcatus* took the biggest share in the percentage contribution of basal area (36.6%) of the vegetation (the most important woody species in the vegetation).



Figure 11. *Podocarpus falcatus* (Podocarpaceae)

➤ DBH class 9 has the highest contribution from the other DBH classes to the total basal area.

Table 12. Contribution of different DBH classes to the total density and basal area/ha in Dugda Dawa District vegetation.

DBH Class	Density		Basal Area	
	No. of stems	%	m ²	%
1	430.42	41.90	1.13	1.25
2	248.75	24.20	10.30	11.40
3	127.50	12.40	19.30	21.35
4	130.00	12.70	13.30	14.70
5	7.92	0.80	0.04	0.04
6	25.83	2.50	2.60	2.90
7	4.17	0.40	4.70	5.20
8	2.50	0.20	9.10	10.06
9	50.83	4.90	29.90	33.08
Total	1027.9	100	90.4	99.98

Legend: DBH class 1 = 3 -7 cm, 2 = 8 - 12 cm, 3 = 13 - 17 cm, 4 = 18 - 22 cm, 5= 23 - 27 cm, 6 = 28 - 32 cm, 7 = 33 - 37 cm, 8 = 38 - 42 cm and 9 > 42 cm.

4.3.4. Density, frequency and dominance

- *Olea europaea* subsp. *cuspidata*, *Podocarpus falcatus*, *Combretum molle*, and *Acokanthera schimperi* were the four most abundant species and constitutes about 28.02% of the total density.
- *Olea europaea* subsp. *cuspidata*, *Croton macrostachyus*, *Acokanthera schimperi*, and *Combretum molle* were the most frequently occurring species.

4.3.5. Importance value index

- *Podocarpus falcatus*, *Olea europaea* subsp. *cuspidata*, *Croton macrostachyus*, *Combretum molle*, *Psydrax schimperiana*, *Acokanthera schimperi*, and *Celtis africana* were the first seven most important species with higher IVI values.
- 67.26, 22.01, 19.67, 17.87, 15.48, 15.23, 12.55 respectively
- This is mainly because of their high dominance and density which is due to their security being found in relatively protected area.

4.3.6. Dominant species of Dugda Dawa District vegetation

- Species having IVI value above 5.00 are referred to as dominant because of:
- the relative ecological importance they played in the vegetation;
 - their abundance in distribution and high basal area within the vegetation.

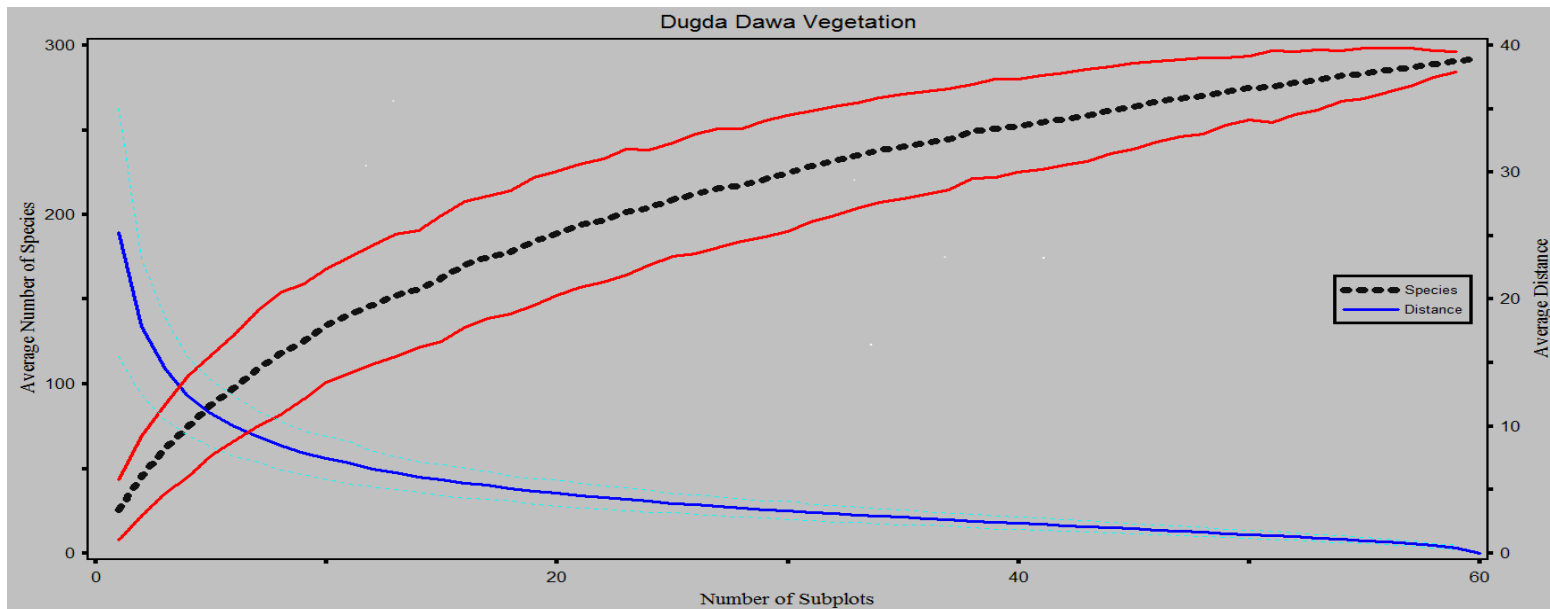


Figure 12. Dominance curve showing the distribution of abundance among species in the study area

4. 3.7. Population structure

Analysis of the population structure of four representative tree species in the vegetation of Dugda Dawa District revealed four general patterns (Figure 13a - d).

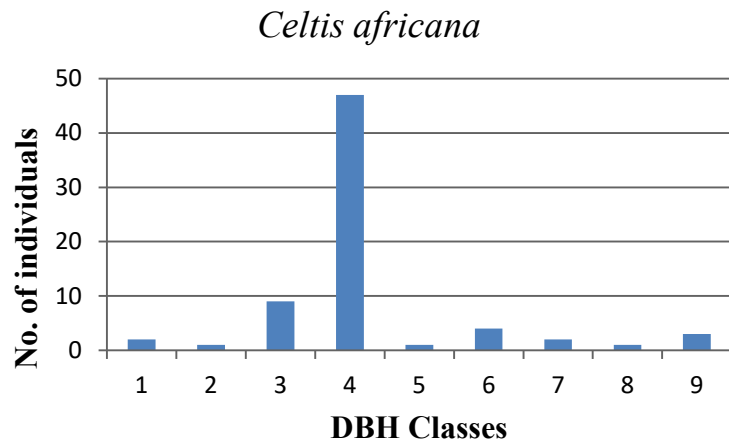


Figure 8a

Figure 8a = Bell-shaped distribution formed by species with high number of individuals in the middle DBH classes .

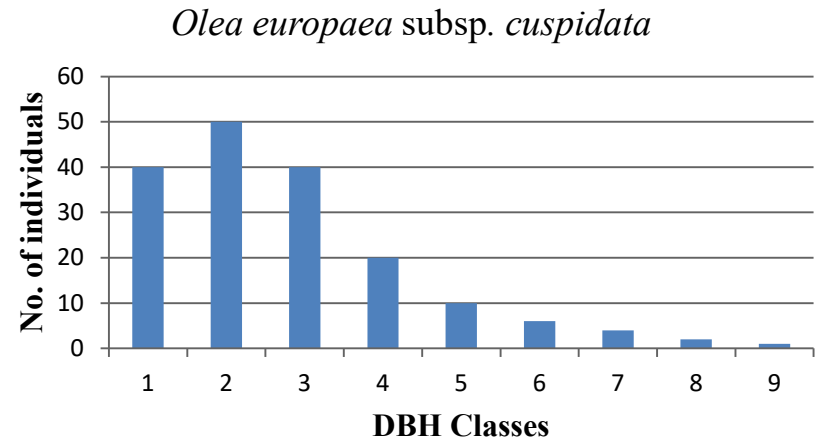


Figure 8b

Figure 8b = Species with positively skewed distribution (inverted J-curve). These species had the highest density in the lower DBH with gradual decrease in density towards the bigger sizes, which suggested good reproduction and healthy regeneration potential in the vegetation

Cont.

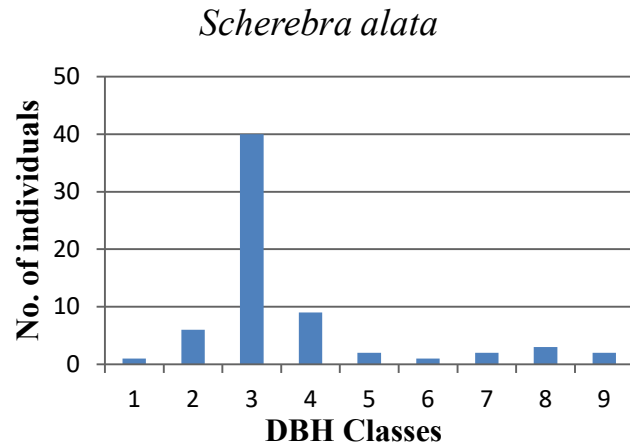


Figure 8c

Figure 8c = was formed by species having irregular distribution over diameter classes. Some diameter classes were poorly represented indicating selective removal of specific sized individuals while other diameter classes are well represented (Gauss-type distribution pattern) .

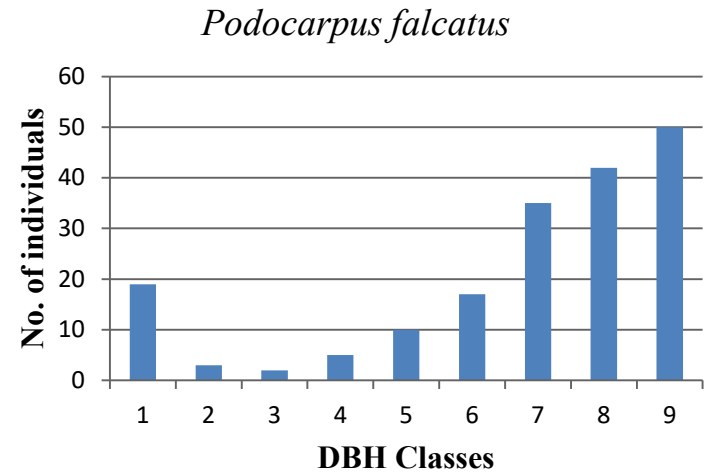


Figure 8d

Figure 8d = was a U-shaped curve formed by species with little or no representatives in the middle DBH classes and represented only by the lower and higher DBH classes.

4.3.8. Phytogeographical comparison of similarity

- Dugda Dawa District vegetation was compared with seven other dryland vegetation in the country using Sorensen's Similarity index to know the similarity of species in the vegetations.
- It shared significant number of species with Sire Beggo woodland vegetation (in Oromia Region, Arsi Zone, Gololcha District) (Abiyot Dibaba *et al.*, 2014) with Sorensen's coefficient of similarity value 0.31

4.3.9. Regeneration status of the vegetation of Dugda Dawa District

- Regeneration of a particular species **is poor if** seedlings and saplings **are much less** than the mature trees.
- The total seedling, sapling, and mature woody tree densities of 34 selected tree species were about 410, **136**, and 565.41 individuals per hectare respectively.
- The **composition**, **distribution**, and **density** of seedlings and saplings are **indicators** of the future regeneration status of any vegetation.

4.4. Ethnobotanical profile of Dugda Dawa District

- DDD is gifted with diverse and unique floras;
- The inhabitants have well developed indigenous knowledge in using plant resources for different purposes.

4.4.1. Traditional medicinal plants in the study area

- Traditional medicinal plants are used in treating and preventing specific ailments and diseases that affect human beings and livestock in the study area.
- There are numerous medicinal plants in the study area for most of which their medical activities have not investigated yet.

4.4.1.1. Taxonomic diversity of medicinal plants

- 127 medicinal plant species that belong to 123 genera and 82 families were collected.
- Of which two bryophytes, one gymnosperm and 79 angiosperm families (two monocots and 77 dicots) were reported.
- Seven of the medicinal plants were obtained from cultivated area (homegarden or farmland), where as the other 120 species were collected from the wild.
- Of the 127 species:
 - 81 species (64.6%) were cited for their uses to treat human ailments;
 - 24 species (18.9%) for treating livestock ailments;
 - 22 species (16.5%) for their therapeutic uses in both humans and livestock .

- Fabaceae was with the highest number of medicinal plant species (13 species) followed by Asteraceae (9 species) and Lamiaceae (9 species).
- Six medicinal plant species collected from the District (*Bothriocline schimperii*, *Erythrina brucei*, *Leucas abyssinica*, *Lippia adoensis*, *Millettia ferruginea* and *Thunbergia ruspolii*) were found to be endemic to Ethiopia.

4.4.1.2. Distribution of medicinal plant species across plant communities

- Traditional medicinal plants were found distributed in each of the identified plant community types in the vegetation :
 - Community type one contained 39 medicinal plant species
 - Community type two contained 58 medicinal plant species
 - Community type three contained 61 medicinal plant species
 - Community type four contained 32 medicinal plant species

Table 15. Medicinal plant species richness, diversity and evenness values of plant communities in Dugda Dawa District vegetation

Community type		Medicinal plant richness	Shannon - Wiener diversity index (H') of medicinal plants	H' max (lns)	Evenness (H'/H' max) of medicinal plants
1	<i>Nuxia oppositifolia</i> - <i>Calpurnia aurea</i> community type	39	3.43	6.69	0.51
2	<i>Faurea speciosa</i> - <i>Terminalia schimperiana</i> community type	58	3.79	7.34	0.52
3	<i>Boscia mossambicensis</i> - <i>Lannea schimperi</i> community type	61	3.77	7.29	0.52
4	<i>Margaritaria discoidea</i> - <i>Maytenus undata</i> community type	32	3.19	6.39	0.50

4.5. Medicinal plants used to treat only human ailments

4.5.1. Diversity of reported medicinal plants

- 81 medicinal plant species belonging to 77 genera and 51 families were reported to be used for treating human ailments in Dugda Dawa District .
- Fabaceae was represented by the highest number of species (10 species, 7.9%), followed by Lamiaceae (seven species, 5.5%), Asteraceae and Rubiaceae four species (3.2%) each.
- 33.3% of the families were represented by more than one medicinal plant species.
- Four medicinal plant species (*Bothriocline schimperi*, *Erythrina brucei*, *Lippia adoensis* and *Millettia ferruginea*) which are used to treat human ailments were endemic to Ethiopia.

- Shrubs (30 species; 37%) were more dominant than trees (23 species; 28.4%) and lianas (13 species; 16.1%).
- The lower forms such as herbs, climbing herbs and epiphytes were 10 species (12.5%), three species (3.7%), and two species (2.5%) respectively.

4.5.2. Parts of medicinal plants used for remedy preparation

- Even though about **eight different plant parts** were reported to be used for remedy preparation, larger proportion (36.6%) of the preparations for treating human ailments were obtained from leaves followed by roots (21.9%) and barks (17.9%).

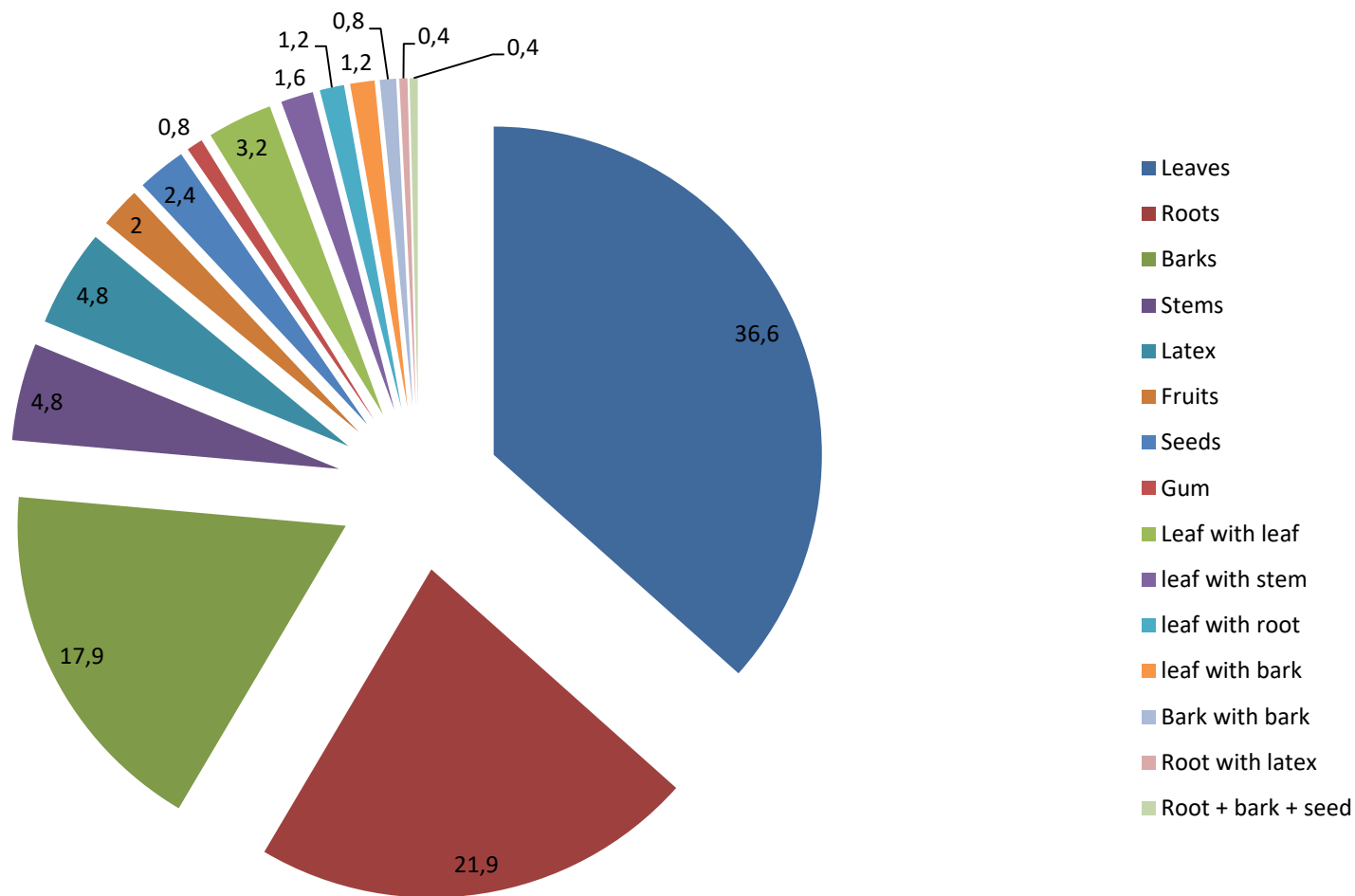


Figure 16. Parts of medicinal plants used (%) for remedy preparation to treat human ailments in Dugda Dawa District

4.5.3. Types of diseases and treatment methods

- About 49 disease types, affecting humans, were identified to be treated with traditional medicinal plants.
- Gastro - intestinal diseases such as tooth ache, stomach ache, and diarrhea were the most frequently reported human ailments followed by skin and venereal diseases.
- These diseases were diagnosed commonly through interviewing and visual inspection of the patients.
- Once the healer gets the required information, herbal medicines were prepared and administered following the proper route and the type of disease.

- Patients with gastro - intestinal problems, STDs, malaria, hepatitis, hypertension, diabetics, TB, rabies and poisons were commonly reported to be treated with **liquid** preparations or **chewable** plant parts given orally.
- Those with different skin diseases and tissue cancer were reported to be treated with **crushed** or **chopped** preparations through rubbing or pasting herbal preparations.
- Diseases such as febrile illness, head ache and evil eye were reported to be treated either through **fumigation** or **washing** the patient with liquid herbal preparations.

4.5.4. Mode of herbal medicine preparation and application

- Mode of preparation and application of remedies varies based on the type of ailment which they identify with reference to symptoms observed on patients.
- Major mode of herbal medicine preparation for human ailments were:
 - Chopping or pounding and homogenizing plant parts (35.6%)
 - Followed by crushing and put on plant parts (16.7%) and;
 - Chopping, homogenizing and boiling plant parts (15%).

4.5.5. Route of remedy administration

- Oral application was the most common route of administration (162 preparations, 70.1%) followed by dermal administration (49 preparations, 21.2%).
- Nasal administration (12 preparations, 5.2%);
- Administration through deep opening on the body formed due to infection “Luxaa - in local Oromo language” (five preparations, 2.2%);
- Aural (two preparations; 0.9%);
- Ocular (one preparation; 0.4%).

4.5.6. Dosages and antidotes

- Remedies are prescribed and given without fixed standards or doses.
- Approximate amount were mentioned to be determined based on gender, age and physical appearance of the patient.
- Remedies were reported to be measured in coffee cups, water glasses, liters while others were measured as handful or pieces of particles.
- Milk, yoghurt, honey, and coffee were mentioned as antidotes for traditional medicines with adverse side effects.

4.5.7. Marketability of medicinal plants

- In the culture of Guji Oromo (ethnic group of the study area) it is forbidden to sell traditional medicine in the open market.
- People coming from other areas usually sell them, the local people didn't accept it.
- In fact there are some medicinal plants sold in the market for different purposes other than their medicinal uses such as;
 - *Coffea arabica* and *Rhamnus prinoides* to be used in the preparation of drinks;
 - *Ruta chalepensis* to be used as spice in milk preparation;
 - *Combretum molle*, *Olea europaea* subsp. *cuspidata* and *Osyris quadripartita* for fumigation in producing good odor and feeling for the body and house.

4.5.8. The most preferred medicinal plants for treating human ailments

Table 16. Results of preference ranking of ten medicinal plants reported for treating tooth ache

Medicinal plants used for tooth ache	Informants designated A to J										Total	Rank
	A	B	C	D	E	F	G	H	I	J		
<i>Acmella caulirhiza</i>	8	7	6	7	6	8	7	6	8	6	69	10 th
<i>Capparis tomentosa</i>	8	9	7	6	8	9	7	8	7	6	75	7 th
<i>Carissa spinarum</i>	9	10	10	9	10	9	9	10	10	9	95	2 nd
<i>Clerodendrum myricoides</i>	8	8	7	9	10	7	8	9	8	8	82	4 th
<i>Fagaropsis angolensis</i>	8	9	8	10	8	9	7	8	9	8	84	3 rd
<i>Pappea capensis</i>	7	6	7	8	7	8	6	6	8	7	70	9 th
<i>Pittosporum viridiflorum</i>	8	8	9	7	8	7	9	8	7	8	79	5 th
<i>Premna schimperi</i>	7	8	7	8	8	6	7	8	7	8	74	8 th
<i>Rhoicissus revoilii</i>	9	7	6	8	7	7	8	9	7	9	77	6 th
<i>Scherebra alata</i>	10	10	9	9	10	10	10	9	10	10	97	1 st

N.B. Scores in the table indicate ranks given to medicinal plants based on their efficacy.

4.5.9. Identification of multipurpose medicinal plants for their conservation priority

Table 17. **Five** use diversities of **ten multipurpose** medicinal **plant species** were listed for **ten** randomly selected key informants to assess their use diversity in direct matrix ranking and the ff results were obtained:

Medicinal plant species	Use categories					Total	Rank
	Ch	Co	Fr & Tl	Fw	Md		
<i>Allophylus abyssinicus</i>	3	3	0	3	2	11	8 th
<i>Combretum molle</i>	5	3	2	3	2	15	4 th
<i>Ehretia cymosa</i>	2	1	0	3	2	8	10 th
<i>Fagaropsis angolensis</i>	3	5	2	4	2	16	3 rd
<i>Olea europaea subsp. cuspidata</i>	3	3	3	5	4	18	2 nd
<i>Pappea capensis</i>	1	3	2	3	3	12	7 th
<i>Podocarpus falcatus</i>	1	1	2	4	1	9	9 th
<i>Schrebera alata</i>	1	3	3	4	3	14	5 th
<i>Terminalia brownii</i>	3	2	2	4	2	13	6 th
<i>Warburgia ugandensis</i>	4	5	4	3	4	20	1 st
Total	26	29	20	36	25	136	
Rank	3 rd	2 nd	5 th	1 st	4 th		

- This exercise enabled to identify which of the multipurpose plants is under greater pressure than other species in the area.

4.5.10. Effectiveness of medicinal plants

Table 18. ICF values of traditional medicinal plants used for treating human ailments in Dugda Dawa District

No.	Disease category	No. of Sp.	% all sp.	Use citations	% all use citations	ICF
1	Dental, oral and pharyngeal	27	13.2	29	9.9	0.07
2	Dermatological	16	7.8	17	5.8	0.06
3	Diabetics, hepatitis and hypertension	12	5.9	13	4.4	0.08
4	Evil spirit	7	3.4	8	2.7	0.14
5	External injuries and snake bite	23	11.2	24	8.2	0.04
6	Febrile	6	2.9	8	2.7	0.29
7	Gastro - intestinal and internal parasites	43	21.0	56	19.0	0.24
8	Musculoskeletal and nervous system	5	2.4	60	20.4	0.93
9	Respiratory	5	2.4	6	2.0	0.20
10	Sensorial	13	6.3	14	4.8	0.08
11	Tissue cancer and cold disease	29	14.2	34	11.6	0.15
12	Urogenital and venereal	19	9.3	25	8.5	0.25

- Selecting traditional medicinal plants by using informant consensus was used to evaluate the reliability of the data.

4.5.11. Relative healing potential of medicinal plants used for treating human ailments

Table 19. Fidelity level values of medicinal plants commonly reported against a given human ailment category

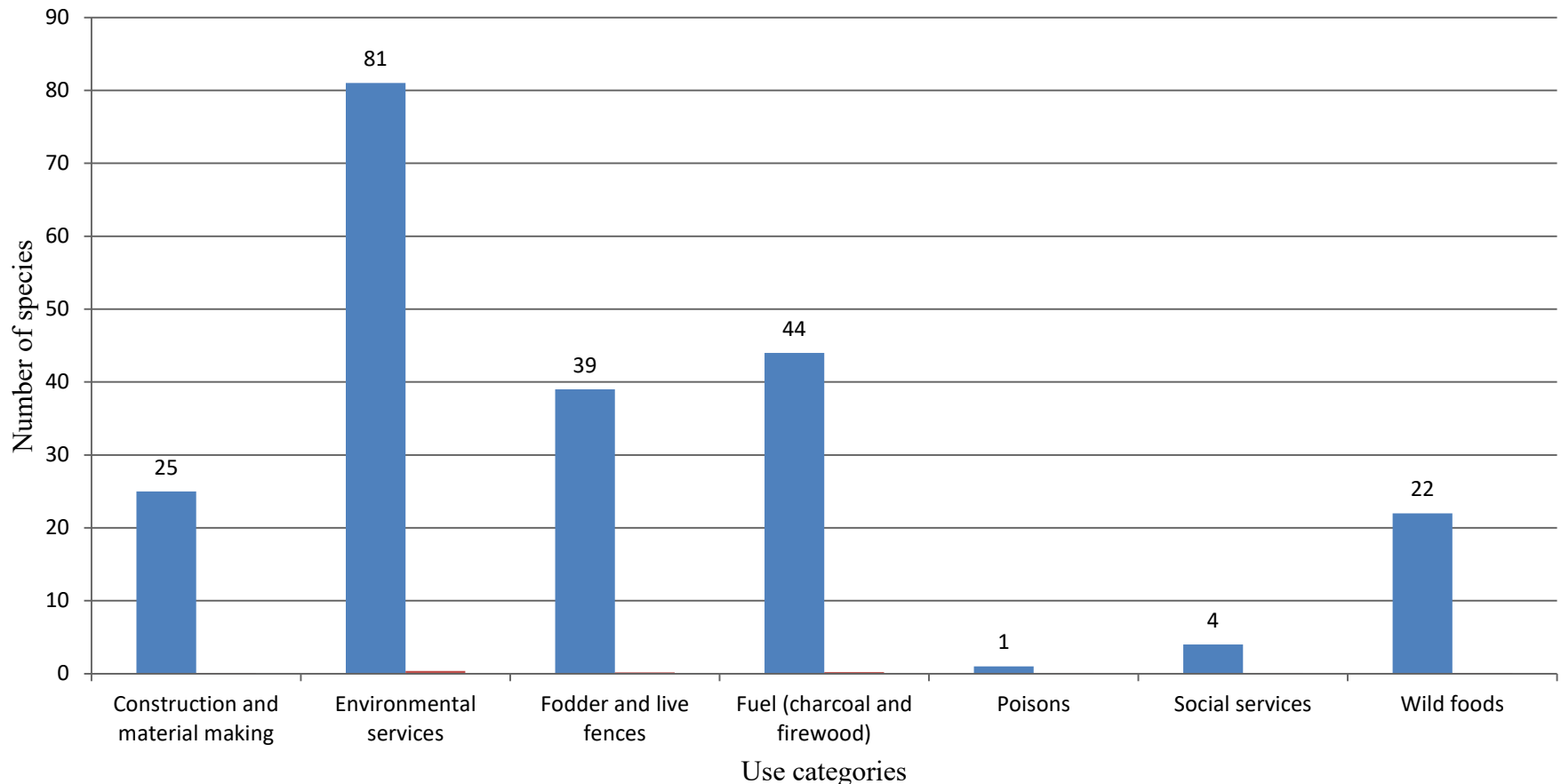
No	Medicinal plant	Therapeutic category	Ip	Iu	FL (%)
1	<i>Carica papaya</i>	Diabetics, hepatitis and hypertension	11	14	79
2	<i>Clerodendrum myricoides</i>	Urogenital and venereal	20	21	95
3	<i>Combretum molle</i>	Gastro - intestinal and internal parasites	14	16	88
4	<i>Fagaropsis angolensis</i>	Respiratory	12	15	80
5	<i>Ocimum urticifolium</i>	Febrile	35	36	97
6	<i>Pappea capensis</i>	External injuries and snake bite	16	19	84
7	<i>Rhus vulgaris</i>	Dermatological	10	12	83
8	<i>Schrebera alata</i>	Dental, oral and pharyngeal	13	15	87
9	<i>Warburgia ugandensis</i>	Tissue cancer and cold disease	18	19	95
10	<i>Withania somnifera</i>	Evil spirit	23	24	96

Legend: FL= Fidelity Level, Ip = number of informants who independently cited the importance of a species for treating a particular disease, Iu = total number of informants who reported the plant for any given disease

- Fidelity level values exercise helped to know healing potential of the reported medicinal plants against the corresponding diseases.

4.5.12. Use diversity of medicinal plants used for humans

- The proportion of medicinal plant species over different use categories is summarized in Figure 18.



4.5.13. Medicinal use values of selected plant species from human medicinal plants

Table 20. Medicinal use values (UVmed) of most-cited human medicinal plants in Dugda Dawa District

Medicinal plant species	No. informants citing the species	Total citations	No. of ailments treated with	UVmed.
<i>Acmella caulirhiza</i>	110	605	4	5.5
<i>Carissa spinarum</i>	118	980	5	8.3
<i>Clematis hirsuta</i>	92	589	5	6.4
<i>Clitoria ternatea</i>	80	402	4	5.0
<i>Ehretia cymosa</i>	120	912	7	7.6
<i>Fagaropsis angolensis</i>	104	676	6	6.5
<i>Pappea capensis</i>	140	1232	8	8.8

N.B. UVmed= Medicinal use value

4.6. Ethnoveterinary medicinal plants

4.6.1. Medicinal plant diversity used only for ethnoveterinary in Dugda Dawa District

- 24 ethnoveterinary medicinal plant species representing 24 genera and 17 families were identified in the district.
- The highest number of species was recorded for Asteraceae (four species) followed by Acanthaceae, Anacardiaceae, Lamiaceae and Vitaceae (two species each).
- Two species (*Leucas abyssinica* and *Thunbergia rurspolii*) of the ethnoveterinary medicinal plants of Dugda Dawa District were endemic to Ethiopia.
- Climbers were dominant growth forms (eight species) followed by shrubs and herbs (five species each).
- All the documented ethnoveterinary plant species were harvested from the wild

4. 6.2. Livestock ailments and their prevalence

- 35 veterinary ailment types were identified in the study area for which informants reported to use one or more medicinal plant species.
- Diarrhea and breathing problems were found to be the most commonly reported types of livestock ailments in the district.

4.6.3. Applications of ethnoveterinary remedies

- The majority of the reported medicinal plant species (21 species) were found to be applied to treat one or more of the fourteen different cattle ailments.
- Eight species were mentioned to be used specifically against goats/sheep and camels ailments respectively .

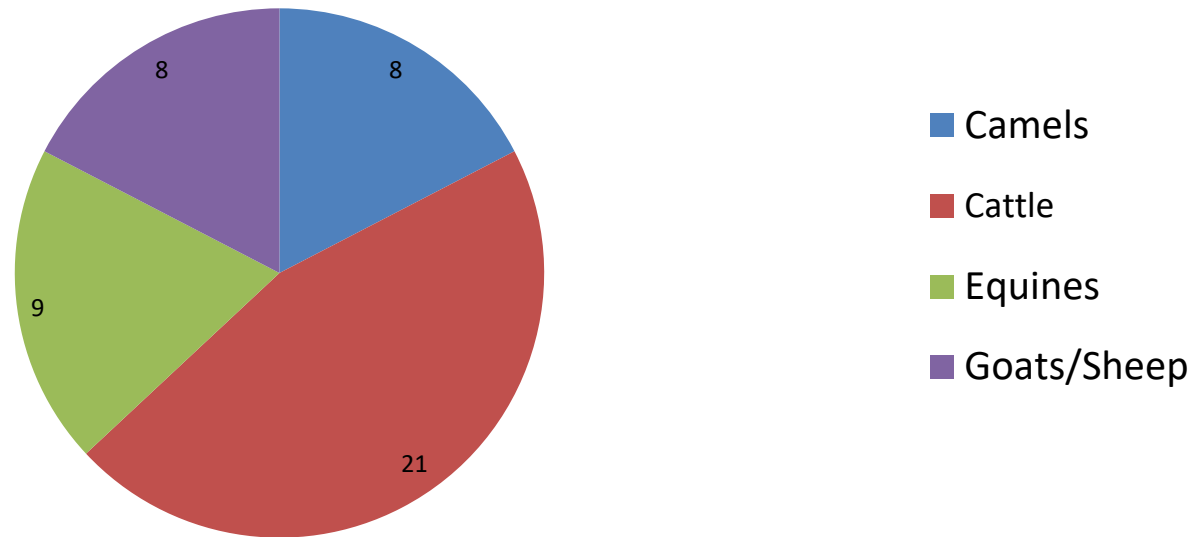
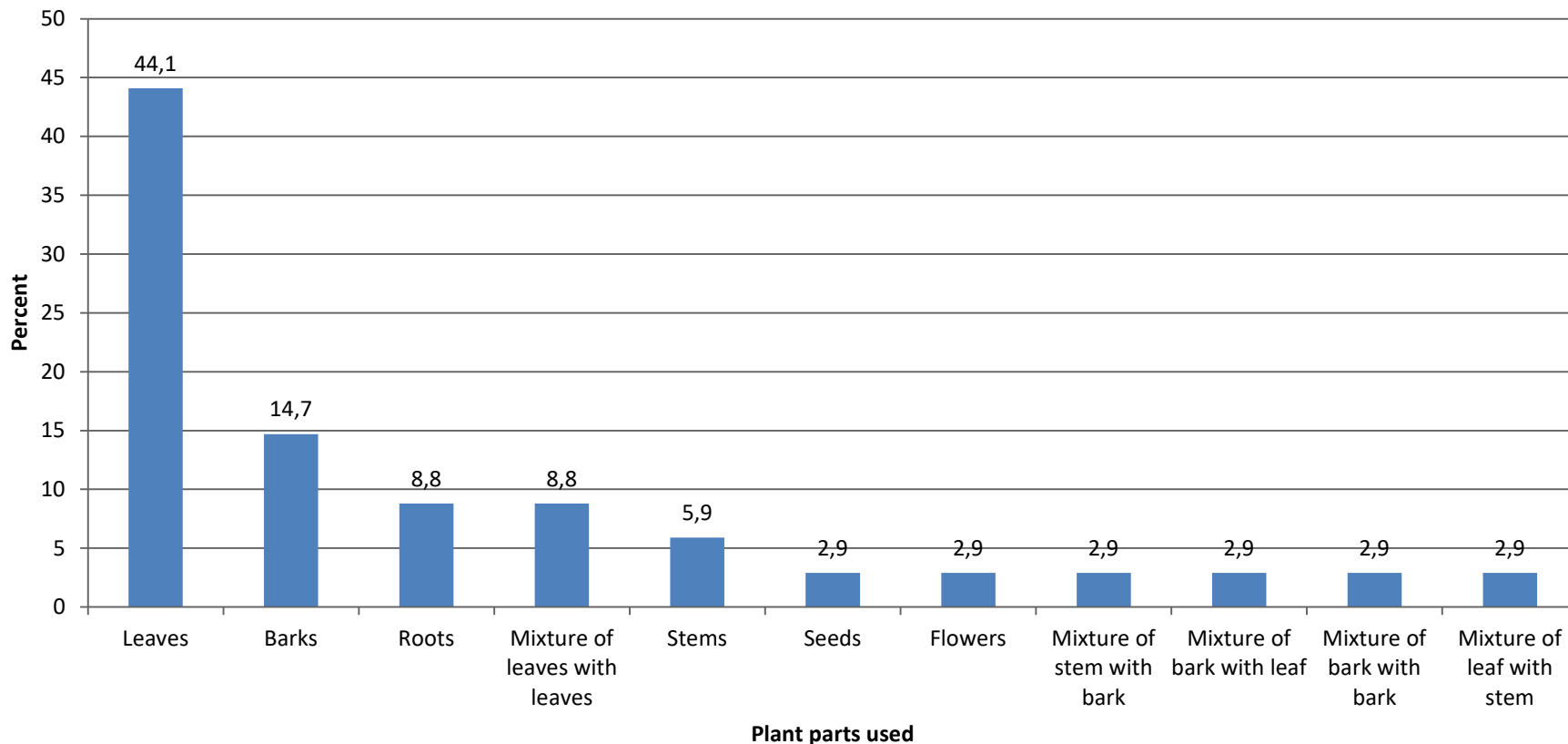


Figure 19. Number of ethnoveterinary plant species used for different livestock types in Dugda Dawa District

4.6.4. Medicinal plant parts used for ethnoveterinary remedy preparation

- Most of the preparations was found to be from leaves alone (44.1%), followed by barks (14.7%) - Figure 20.

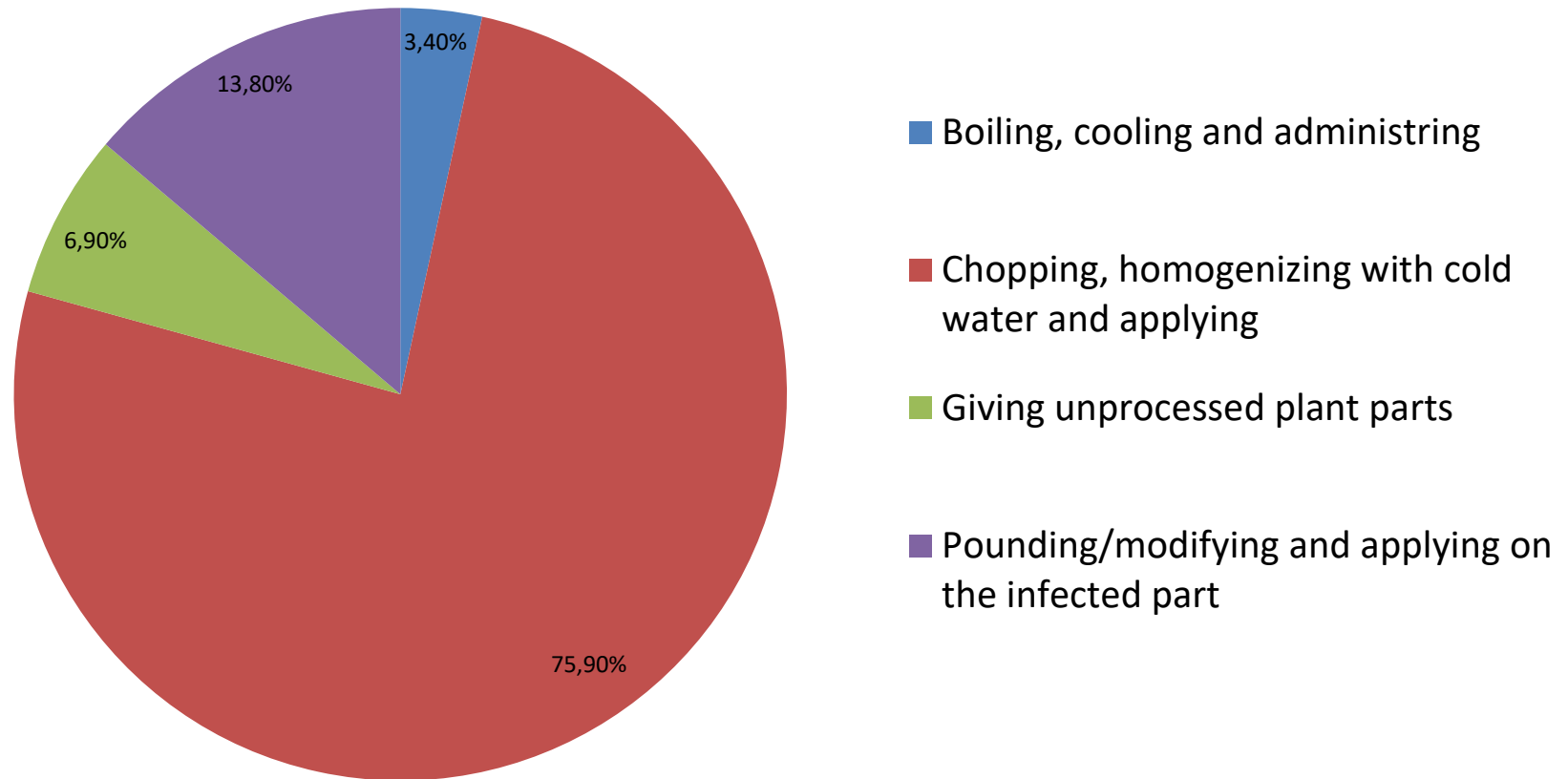


- All remedies (100%) were prepared from freshly harvested plant parts

4.6.5. Approach of remedy preparation, routes of administration and dosages

- Pounding/chopping/crushing the remedial part and homogenizing it with cold water was found to be the major mode of remedy preparation (93.1%);
- Unprocessed forms cover only (6.9%) - Figure 21.

- Medicinal preparations were reported to be given through oral, dermal, or nasal routes.
- Oral application was the most-cited route of administration (20 preparations, 66.7 %) followed by nasal (six preparations, 20%).



- Physical appearance of the diseased animal and visually confirmed degree of complexity of illness are used to determine the doses of the remedy prepared.
- Coffee cup, water glasses, bottles, a small dish and finger tips were some of the materials used to determine doses.
- No standardized doses of herbal preparations were reported by traditional practitioners for any of the remedies used to treat livestock ailments.

4.6.6. Preference ranking of ethnoveterinary plants

- Preference ranking exercise of medicinal plants reported for **treating breathing system diseases** of livestock was done with **10 key informants** and the result is shown with Table 21.

Plant spp. treating breathing system diseases of livestock	Informants designated A to J										Total score	Rank
	A	B	C	D	E	F	G	H	I	J		
<i>Ammocharis tinneana</i>	4	3	4	5	5	6	7	6	5	5	50	7 th
<i>Clematis simensis</i>	6	8	7	8	6	5	8	6	7	8	69	1 st
<i>Heteromorpha arborescens</i>	7	6	8	5	4	6	5	3	6	7	57	5 th
<i>Lannea rivae</i>	8	6	5	7	6	4	6	7	5	6	60	3 rd
<i>Leucas abyssinica</i>	5	4	4	6	5	3	4	5	6	3	45	8 th
<i>Phytolacca dodecandra</i>	6	5	5	6	7	4	5	6	3	6	53	6 th
<i>Senecio hadiensis</i>	7	8	6	7	5	8	6	4	4	4	59	4 th
<i>Viscum congolense</i>	8	7	6	8	5	4	6	5	7	6	62	2 nd

N.B. Scores in the table indicate ranks given to medicinal plants based on their efficacy (highest number (8) was given for the medicinal plant which informants thought most effective in treating breathing system diseases and the lowest number (3) was given for the least effective plant.

4.6.7. Multipurpose medicinal plants used for livestock ailments and their conservation status

Table 22. Average direct matrix ranking score of ten key informants for five medicinal plant species with six use diversities

Medicinal plant species	Use categories						Total	Rank
	Ch	Co	Fr & Tl	Fw	Md	We		
<i>Combretum collinum</i>	5	2	2	5	3	0	17	3 rd
<i>Dichrostachys cinerea</i>	5	4	1	3	3	0	16	4 th
<i>Lannea rivae</i>	2	2	1	3	3	2	13	5 th
<i>Prunus africana</i>	4	5	4	5	5	0	23	1 st
<i>Syzygium guineense</i> var. <i>guineense</i>	3	5	3	5	3	3	22	2 nd
Total	19	18	11	21	17	5	91	
Rank	2 nd	3 rd	5 th	1 st	4 th	6 th		

Where, Ch = Charcoal, Co = Construction, Fr & Tl = Furniture and Tools, Fw = Firewood, Md = Medicinal and We = Wild edible

This exercise enabled to identify which of the multipurpose plants is under greater pressure than other species in the area besides the respective factors that threaten the plants

4.6.8. Effectiveness of ethnoveterinary medicinal plants

Table 23. ICF values of traditional medicinal plants used for treating livestock ailments was computed and the results were obtained:

No	Disease category	No. of species	% of all species	Use citations	% of use citations	ICF
1	Black leg, hepatitis and FMD	5	20.8	24	17.1	0.83
2	Breathing system diseases	5	45.8	42	30.0	0.90
3	Dermatological diseases	3	12.5	16	11.4	0.87
4	Gastro - intestinal diseases	8	33.3	40	28.6	0.82
5	Muscular - nervous system diseases	7	29.2	10	7.1	0.33
6	Tooth ache, leech infection and cold	4	16.7	8	5.7	0.57

➤ The highest plant use citation (30%) was recorded for breathing system diseases.

4.6.9. Comparative healing potential of ethnoveterinary medicinal plants

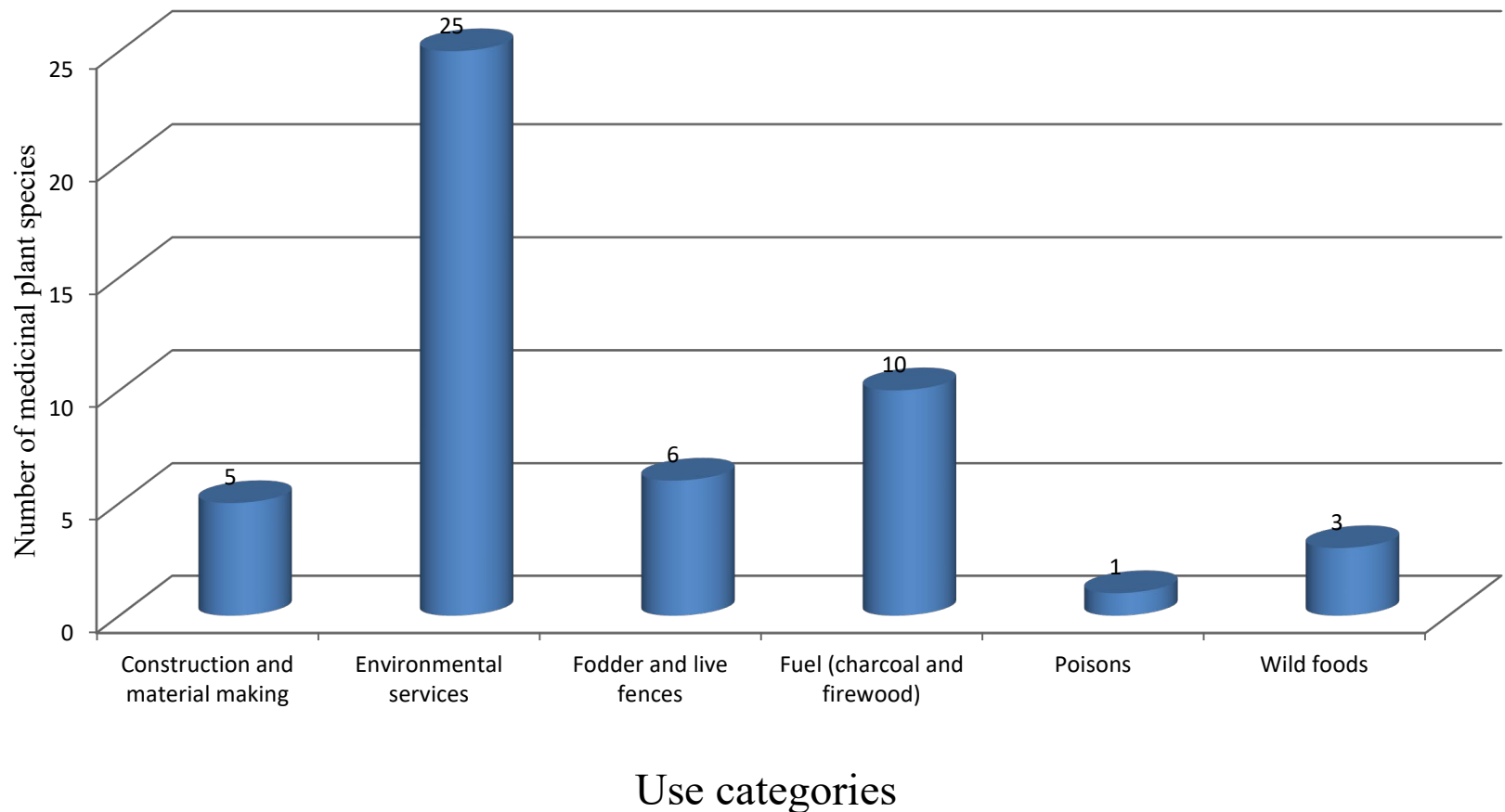
Table 24. Fidelity level values of medicinal plants commonly reported against certain livestock ailment category was computed as follows:

No.	Medicinal plant	Healing category	Np	N	FL value (%)
1	<i>Cyphostemma serpens</i>	Black leg, hepatitis and FMD	32	33	97.00
2	<i>Ozoroa insignis</i>	Muscular -nervous system diseases	26	30	87.00
3	<i>Prunus africana</i>	Dermatological diseases	24	26	92.00
4	<i>Syzygium guineense</i>	Tooth ache, leech infection and cold	12	16	75.00
5	<i>Tragia cinerea</i>	Gastro - intestinal diseases	20	24	83.00
6	<i>Viscum congolense</i>	Breathing system diseases	22	23	96.00

N.B. FL= Fidelity Level, Np = number of informants who independently cited the importance of a species for treating a particular disease, N = total number of informants who reported the plant for any given disease

4.6.10. Use diversity of medicinal plants used for livestock

Figure 22. Proportion of livestock medicinal plants in Dugda Dawa District over different use categories was computed as follows:



4.6.11. Medicinal use values of selected plant species from livestock medicinal plants

Table 25. Medicinal use values (UVmed) of most-cited livestock medicinal plants was computed as follows:

Medicinal plant species	No. informants citing the species	Total citations	No. of ailments treated with	UVmed.
<i>Cyphostemma serpens</i>	84	504	2	6.0
<i>Datura</i> sp.	68	374	2	5.5
<i>Dichrostachys cinerea</i>	96	749	2	7.8
<i>Lannea rivae</i>	118	944	2	8.0
<i>Ozoroa insignis</i>	102	673	2	6.6

N.B. UVmed = Medicinal use value

4.7. Ethnobotanical study of medicinal plants used for both humans and livestock

4.7.1. Diversity of medicinal plants used for both humans and livestock

- 22 medicinal plant species representing 20 genera and 14 families used for both humans and livestock were identified.
- Five families were represented by more than one species i.e.
- Euphorbiaceae, Rubiaceae and Rutaceae were with three species and Apiaceae and Solanaceae were with two species each.
- Shrubs were greater in number than other growth forms (ten species) followed by trees (six species).
- 20 species of the documented medicinal plant species were harvested from the wild whereas two species were cultivated.



Figure 23. *Acokanthera schimperi* - Apocyanaceae
(medicinal plant used for humans and livestock
plus wild edible) = Representative of wild species

4.7.2. Ailments treated with medicinal plants used for both humans and livestock

- 33 human and 27 veterinary ailment types were identified;
- **Seven** ailment types **in humans** and **six** ailment types in **livestock** belong to the gastro - intestinal and internal parasite disease category;
- Diarrhea and tooth ache diseases in humans and coughing in livestock were found to be the most commonly reported form of ailments in the district;

Cont.

- Healers treat these ailments based on observation, and/or information obtained by interviewing the patient or livestock owners about major symptoms shown by the diseased animals;
- Applying pounded remedies on the infected tooth and oral administration of homogenized herbal preparations for diarrhea and coughing were reported as the main treatment methods;

4.7.3. Composition and application of remedies for both humans and livestock

- The majority of human and livestock medications (78.3%) were reported to comprise medicinal parts of a single medicinal plant.
- The highest proportion of species was claimed to treat tooth ache and diarrhea/stomach ache (40.9%, nine species each), followed by breathing problem (22.7%, five species).
- *Croton macrostachyus* was used against 13 ailment types followed by *Aloe trichosantha*, *Calpurnia aurea* and *Teclea salicifolia* (each used against five ailment types)

4.7.4. Medicinal plant parts used for both human and ethnoveterinary remedy preparation

- Most of the preparations was found to be from leaves alone (30.2%) followed by roots (20.9%).
- Of these remedies 92.1% were prepared from freshly harvested plant parts.

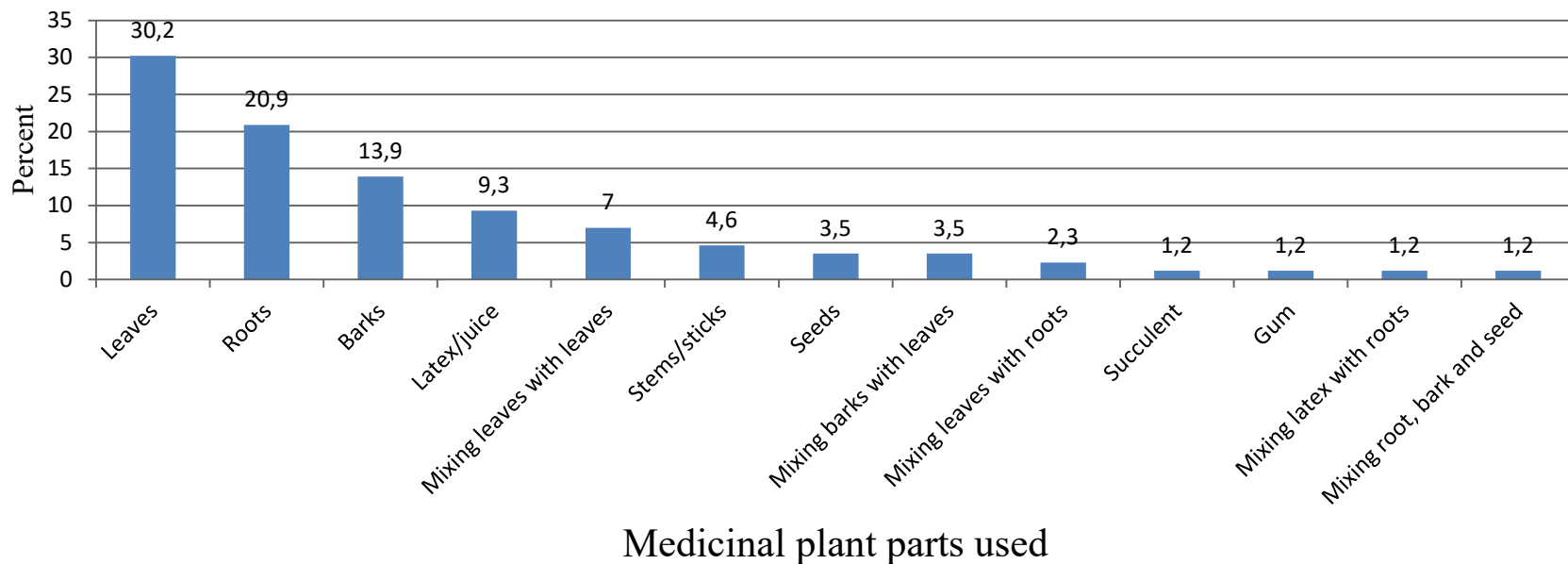


Figure 24. Plant parts used for both human and livestock remedy preparation in Dugda Dawa District

4.7.5. Mode of remedy preparation, routes of administration and dosages

- Pounding the remedial part and homogenizing it with cold water was the major mode of remedy preparation (58.2%) followed by homogenized, boiled and cooled preparation (17.7%).
- Oral, dermal, nasal, aural, and ocular are routes through which traditional remedies were reported to be administered.
- Oral application was the most cited route of administration (67 preparations, 77 %), followed by dermal (15 preparations, 17.2%).

- Physical observation and information from the patient or owner of diseased animal are used to determine preparation doses to treat both humans and livestock ailments.
- Coffee cup, water glasses, a small dish and bottles to determine dosage for some medicinal preparations.
- No standardized doses of herbal preparations were reported by traditional healers.

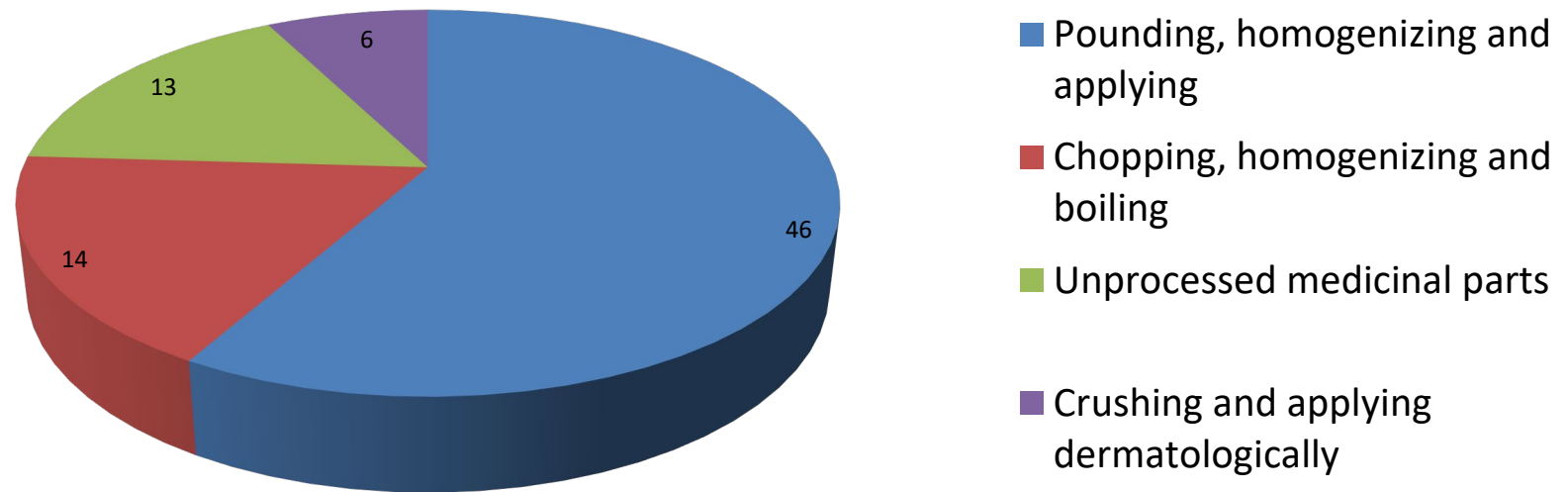


Figure 25. Amounts of remedy preparation and forms of administration of traditional medicines for treating both human and livestock ailments in Dudga Dawa District

4.7.6. Preference ranking of medicinal plants used for both humans and livestock

Table 26. Results of preference ranking exercise performed with 10 key informants on medicinal plants reported for treating hepatitis in both humans and livestock

Plant species treating hepatitis in humans and livestock	Informants designated A to J										Total score	Rank
	A	B	C	D	E	F	G	H	I	J		
<i>Aloe trichosantha</i>	3	5	4	2	3	1	4	2	5	1	30	5 th
<i>Calpurnia aurea</i>	5	3	4	4	4	3	5	3	4	4	39	4 th
<i>Croton macrostachyus</i>	4	5	4	4	5	4	5	3	4	3	41	2 nd
<i>Teclea salicifolia</i>	5	4	3	3	4	5	4	3	5	4	40	3 rd
<i>Vangueria apiculata</i>	3	4	4	5	5	5	4	4	5	4	43	1 st

4.7.7. Conservation status of multipurpose medicinal plants used for both humans and livestock

Table 27. Average direct matrix ranking score of ten key informants for five medicinal plant species with additional uses

Medicinal plant species	Use categories						Total	Rank
	Ch	Co	Fr & Tl	Fw	Md	We		
<i>Balanites aegyptiaca</i>	4	3	2	4	2	3	18	2 nd
<i>Calpurnia aurea</i>	4	4	2	5	4	0	19	1 st
<i>Croton macrostachyus</i>	2	2	3	4	3	0	14	3 rd
<i>Zanthoxylum chalybeum</i>	2	1	2	2	2	2	11	5 th
<i>Ziziphus abyssinica</i>	2	2	2	2	2	2	12	4 th
Total	14	12	11	17	13	7	74	
Rank	2 nd	4 th	5 th	1 st	3 rd	6 th		

- This exercise enabled to identify which of the multipurpose plants is under greater pressure than other species in the area.
- *Calpurnia aurea* was ranked first (most - threatened) followed by *Balanites aegyptiaca*.
- These multipurpose medicinal plant species are currently exploited more for firewood and charcoal purposes than for their medicinal uses

4.7.8. Efficacy of medicinal plants used for both humans and livestock

- Six main ailment categories were identified from the total 60 diseases which were common to humans and livestock;
- The highest ICF values were recorded for gastro - intestinal and internal parasites;
- The highest plant use citation (27.7%) was recorded for gastro - intestinal and internal parasites (Table 28).

Cont.

Table 28. ICF values of traditional medicinal plants used for treating both human and livestock ailments in Dugda Dawa District

No.	Disease category	No. of species	% of all species	Use citation	% of use citations	ICF
1	Gastro - intestinal and internal parasites	12	54.5	66	27.7	0.83
2	Urogenital diseases	9	40.9	46	19.3	0.82
3	Dermatological diseases	6	27.3	28	11.8	0.81
4	Tissue cancer and cold	9	40.9	42	17.7	0.80
5	Hepatitis, muscular - nervous system and snake bite	11	50.0	45	18.9	0.77
6	Sensorial diseases	4	18.2	11	4.6	0.70

4.7.9. Comparative healing potential of medicinal plants used for both humans and livestock

- *Solanum dennekense* showed the highest fidelity level value (93%) for tissue cancer and cold disease category;
- Followed by *Croton macrostachyus* (92%) for urogenital diseases;

No.	Medicinal plant	Remedial category	Np	N	FL value (%)
1	<i>Aloe trichosantha</i>	Dermatological diseases	18	20	90
2	<i>Calpurnia aurea</i>	Sensorial diseases	12	18	67
3	<i>Croton macrostachyus</i>	Urogenital diseases	24	26	92
4	<i>Solanum dennekense</i>	Tissue cancer and cold	14	15	93
5	<i>Teclea borenensis</i>	Gastro - intestinal and internal parasites	21	24	87
6	<i>Vangueria apiculata</i>	Hepatitis, muscular - nervous system and snake bite	11	13	85

N.B. FL= Fidelity Level, Np = number of informants who independently cited the importance of a species for treating a particular disease, N = total number of informants who reported the plant for any given disease.

4.7.10. Use diversity of medicinal plants used for both human and livestock

- All the 22 medicinal plant species recorded were cited for one or more uses other than their medicinal role (26).

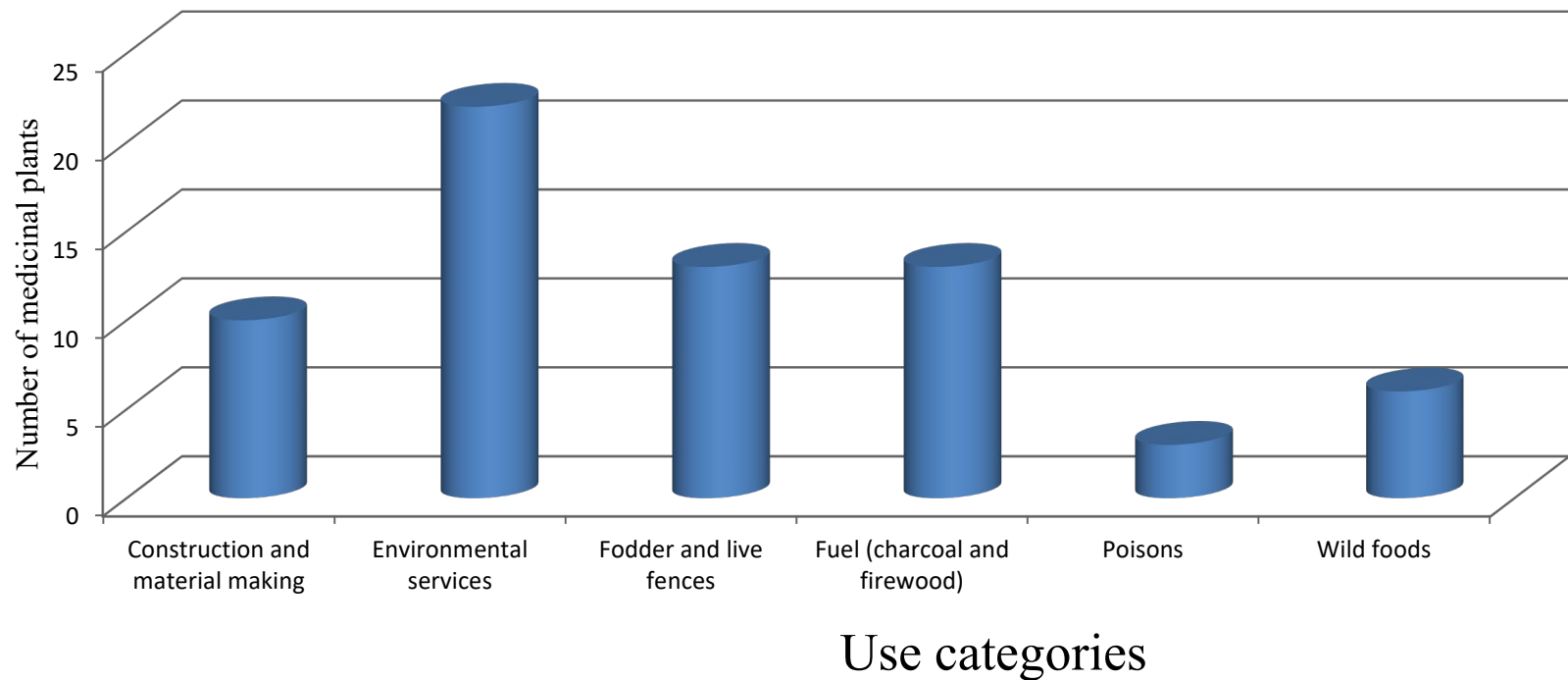


Figure 26. Proportion of medicinal plants for both humans and livestock in Dugda Dawa District over different use categories

4.7.11. Medicinal use values of selected medicinal plant species used for treating both human and livestock ailments

- The highest medicinal use values (UVmed) were recorded for *Croton macrostachyus* (9.2), *Calpurnia aurea* (8.5), and *Zanthoxylum chalybeum* (8.2) (Table 30).

Table 30. Medicinal use values (UVmed) of most cited remedial plants in Dugda Dawa District

Medicinal plant species	No. of informants citing the species	Total citations	No. of ailments treated with	UVmed.
<i>Aloe trichosantha</i>	116	754	6	6.5
<i>Calpurnia aurea</i>	142	1207	6	8.5
<i>Croton macrostachyus</i>	160	1472	13	9.2
<i>Solanum dennekense</i>	96	596	5	6.2
<i>Teclea borenensis</i>	112	829	6	7.4
<i>Teclea salicifolia</i>	130	1014	6	7.8
<i>Zanthoxylum chalybeum</i>	124	1017	6	8.2

N.B. UVmed= Medicinal use value

4.7.12. Solvent and additives used in traditional herbal medicines preparation in the study area

- Almost in all ethno formulations of traditional medicines water served as ‘solvent’ whenever dilution is required.
- Different additives are incorporated in 23.4% of the whole ethno formulations (Figure 27).

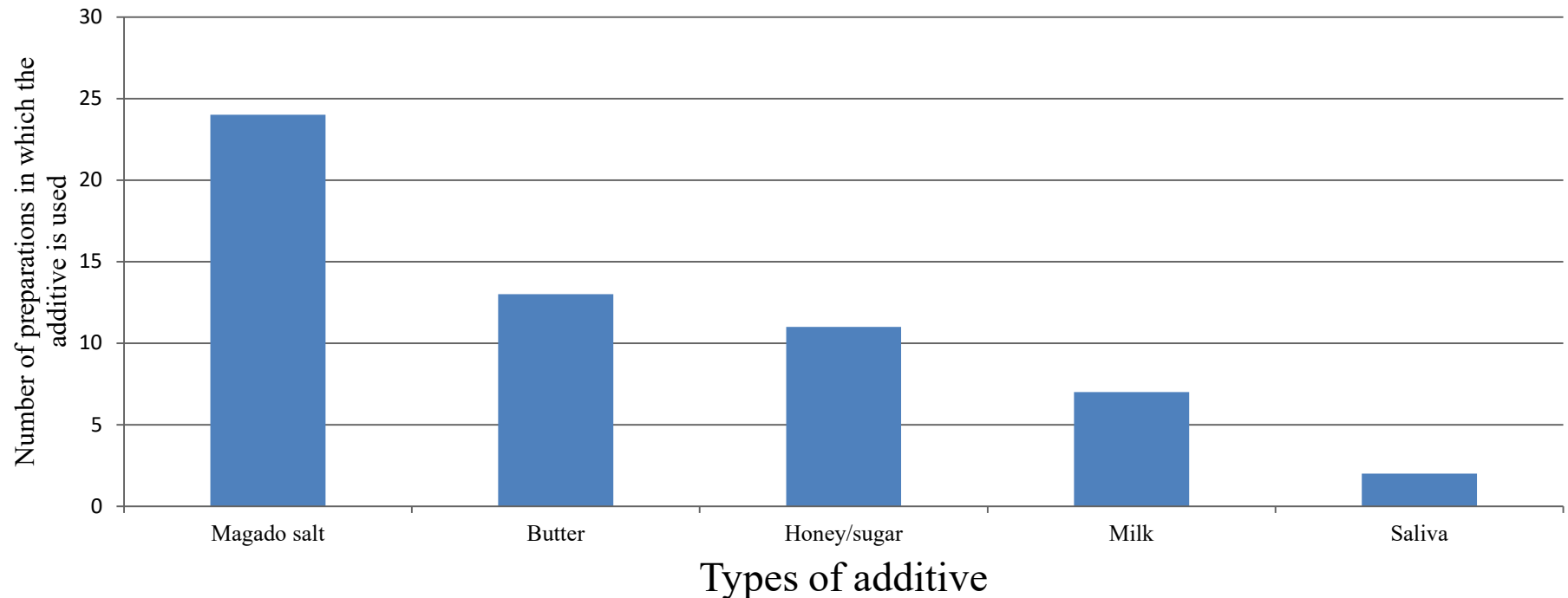


Figure 27. Additives used in traditional herbal remedy preparation in the study area

4. 8. Distribution of indigenous knowledge on medicinal plants among different social groups in the community of the study area

- There were significant differences ($P < 0.05$) in the number of medicinal plants reported by:
 - Elders(> 39 years old) and young- to middle-aged members (< 40 years old);
 - Key informants and randomly taken informants, illiterate and literate informants;
 - More number of medicinal plants was reported by elders (> 40 years old), illiterates, and key informants than by young, literates, and randomly taken informants (Table 31).

Table 31. Statistical test of significance on average number of medicinal plants among different informant groups in Dugda Dawa District

Considerations	Informant groups	N	Average \pm SD	t -value**	p –value
Gender	Males	290	6.62 \pm 2.65	1.97	0.97
	Females	102	6.05 \pm 2.18		
Age	Youngsters	208	5.16 \pm 2.07	-12.87	0.00*
	Elders	184	7.96 \pm 2.19		
Literacy	Illiterates	292	7.22 \pm 2.31	12.92	0.00*
	Literates	100	4.28 \pm 1.82		
Proximity to health center	Near to health center	22	6.00 \pm 2.37	-0.94	0.36
	Far away from health center	370	6.5 \pm 2.57		
Informant category	Key informants	50	10.76 \pm 1.09	25.75	0.00*
	Randomly taken informants	342	5.85 \pm 2.04		

*Significant difference ($p < 0.05$); ** t(0.05) (two tailed), degree of freedom (df) = 223, N= number of respondents

4.9. Ethnobotanical study of wild edible plants in Dugda Dawa District

4.9.1. Taxonomic diversity of wild edible plants

- 71 wild edible plant species that belongs to 52 genera and 37 angiosperm families (two monocots and 35 dicots) were reported ;
- 70 species were collected from the wild;
- One (*Moringa stenopetala*) was semi-wild;
- Regarding their growth forms; trees and shrubs were equally dominant;
- Fabaceae and Anacardiaceae were the most dominant with seven species each;

Cont.

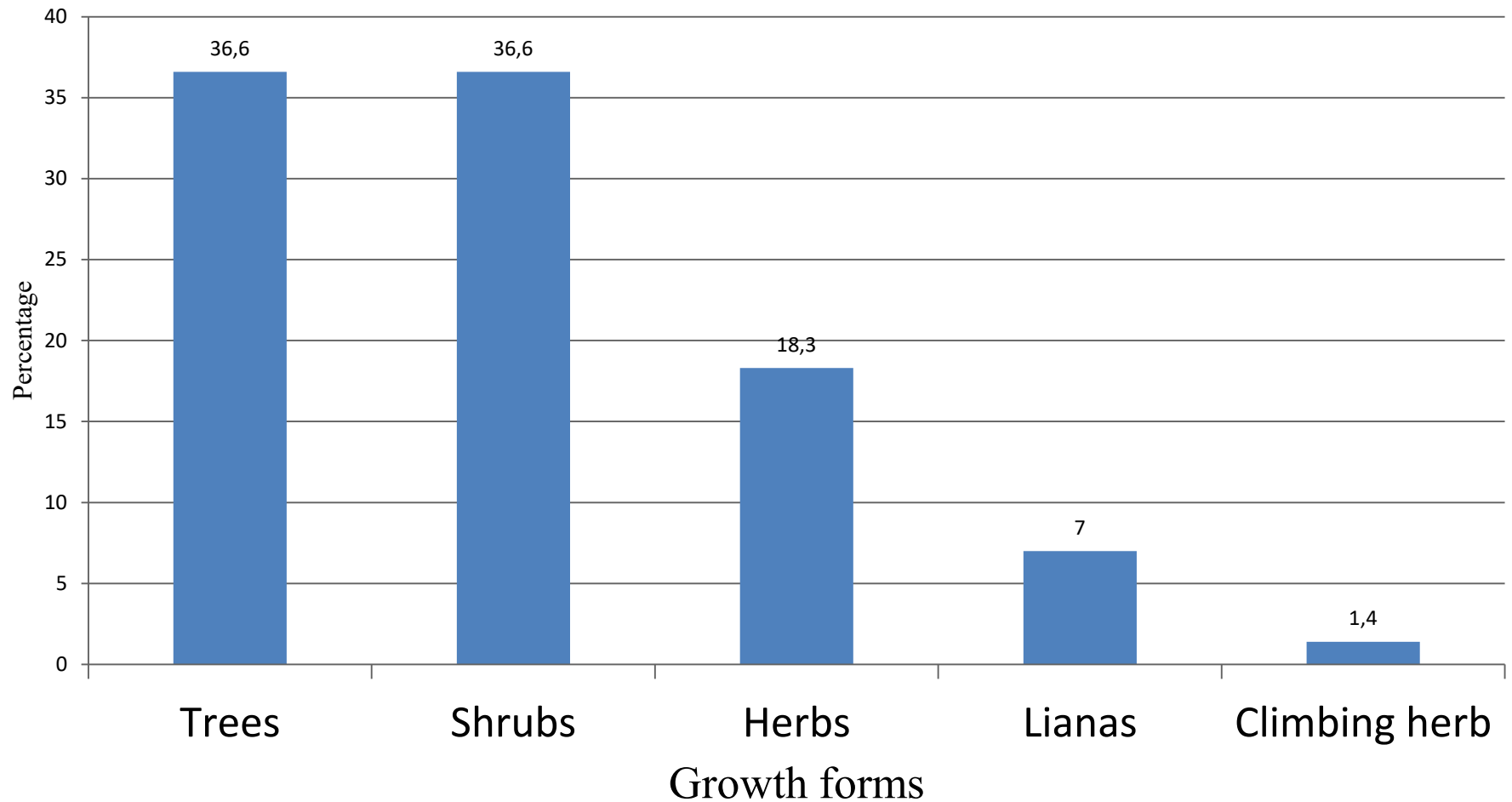


Figure 28. Growth forms of wild edible plants

4.9.2. Distribution of wild edible plant species across plant communities in Dugda Dawa District vegetation

- Community three contains the highest number of wild edible plant species.

Table 32. Wild edible plant species richness, diversity and evenness values of plant communities in Dugda Dawa District vegetation

Community type	Wild edible plant richness	Shannon – Wiener diversity index (H') of wild edible plants	H' max (lns)	Evenness (H'/H' max) of wild edible plants
1	17	2.57	5.48	0.47
2	28	3.02	6.38	0.47
3	41	3.22	6.86	0.47
4	18	2.67	5.86	0.46

4.9.3. The role of wild edible plants in household food security and food use categories

- 7% of the species used during periods of ample food production to supplement the staple diet;
- 78.9% of the species used to fill the gap of seasonal food shortage;
- 14.1% of the species used during famine;

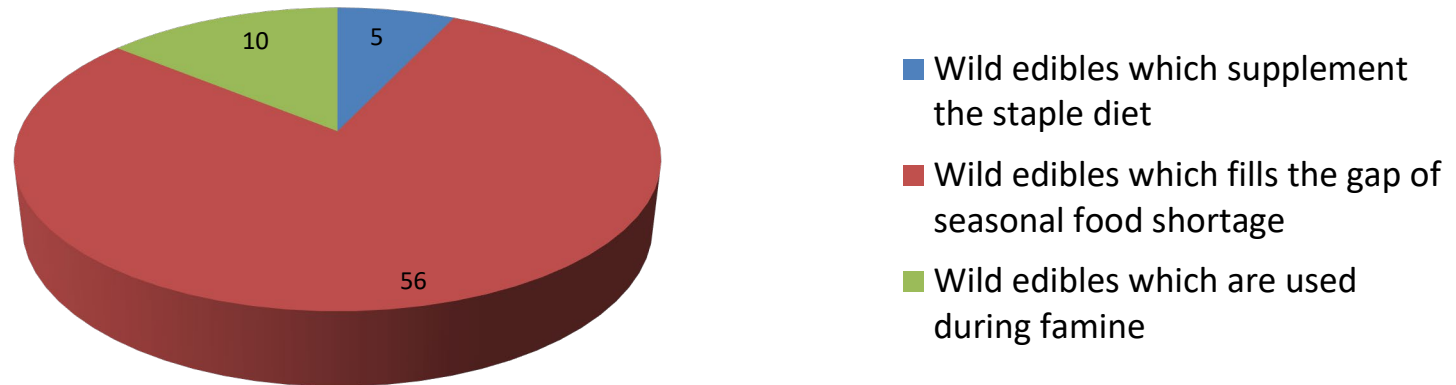


Figure 29. Food use categories of wild edible plant species in Dugda Dawa District

4.9.4. Distribution of indigenous knowledge on wild edible plants among the different social group in the local community

- There was a significant difference ($P < 0.05$) in the number of wild edible plants reported by elders (> 36 years old) and youngsters (< 37 years old);
- key informants and randomly taken informants;
- More number of medicinal plants was reported by youngsters (< 37 years old) and key informants (Table 33).

Cont.

Table 33. Statistical test of significance on average number of wild edible plants among different informant groups

Considerations	Informant groups	N	Average \pm SD	t -value**	p –value
Gender	Males	79	16.99 \pm 2.89	- 0.27	0.79
	Females	51	17.12 \pm 2.49		
Age	Youngsters	99	17.36 \pm 2.64	2.36	0.02*
	Elders	31	16.00 \pm 2.81		
Literacy	Illiterates	68	16.60 \pm 2.72	-1.53	0.13
	Literates	62	17.35 \pm 2.82		
Proximity to health center	Near to the center	22	16.36 \pm 3.18	-1.1	0.28
	Far away from the center	108	17.17 \pm 2.62		
Informant category	Key informants	26	18.92 \pm 1.73	5.36	0.00*
	Randomly taken informants	104	16.57 \pm 2.74		

*Significant difference ($p < 0.05$); ** t(0.05) (two tailed), Average degree of freedom (df) = 75.44, N= number of respondents

4.9.5. Plant parts used and mode of consumption

- Eighty one plant parts were mentioned as food sources;
 - ✓ 54 fruit types;
 - ✓ Eight root types;
 - ✓ Eight bark types,
 - ✓ Seven leave types and;
 - ✓ Seed, stem, nectar, and gum one type each.
- 70 plant parts (86.4%) were consumed uncooked and seven (13.6%) were consumed in their cooked form.

Cont.

➤ Representatives of wild edibles are shown with Figure 31.



Flacourtia indica - Flacouraceae, *Ziziphus abyssinica* - Rhamnaceae, *Amaranthus dubius*
Amaranthaceae

4.9.6. Preference ranking of wild edible plants in the district

- Preference and value ranking exercise showed that *Solanum nigrum* and *Psophocarpus grandiflorus* were the most preferred species used as wild food (Table 34).

Plant species used as wild food	Informants designated A to H								Total score	Rank
	A	B	C	D	E	F	G	H		
<i>Lannea rivae</i>	3	4	3	3	4	4	3	3	27	5 th
<i>Psophocarpus grandiflorus</i>	4	5	4	4	5	4	4	5	35	2 nd
<i>Rhus longipes</i>	3	4	4	3	4	3	4	4	29	4 th
<i>Rhus vulgaris</i>	3	5	4	4	5	3	4	4	32	3 rd
<i>Solanum nigrum</i>	5	4	5	5	4	5	5	4	37	1 st

4.9.7. Determination of multipurpose wild edible plants for their conservation priority

Table 35. Average direct matrix ranking score of ten key informants for ten wild edible plant species with additional uses.

Wild edible plant species	Use categories						Total	Rank
	Ch	Co	Fr & Tl	Fw	Md	We		
<i>Albizia schimperiana</i>	3	2	2	3	2	2	14	10 th
<i>Allophylus abyssinicus</i>	5	5	3	5	3	3	24	1 st
<i>Balanites aegyptiaca</i>	4	3	2	3	3	3	18	7 th
<i>Cordia africana</i>	3	5	5	5	0	4	22	3 rd
<i>Fagaropsis angolensis</i>	3	5	2	5	2	2	19	6 th
<i>Lannea rivaie</i>	3	2	2	3	3	3	16	8 th
<i>Mimusops kummel</i>	3	2	2	4	0	4	15	9 th
<i>Olea europaea</i> subsp. <i>cuspidata</i>	4	4	3	5	4	3	23	2 nd
<i>Pappea capensis</i>	5	2	2	5	2	4	20	5 th
<i>Syzygium guineense</i> subsp. <i>guineense</i>	3	4	2	5	2	5	21	4 th
Total	36	34	25	43	21	33	192	
Rank	2 nd	3 rd	5 th	1 st	6 th	4 th		

Where, Ch = Charcoal, Co = Construction, Fr & Tl = Furniture and Tools, Fw = Firewood, Md = Medicinal and We = Wild edible

4.9.8. Use value of selected wild edible plants species in the district and their domestication possibility

- The highest food use values (UVfo) were recorded for *Psophocarpus grandiflorus*.

Table 36. Food use values (UVfo) of most cited wild edible plants

Wild edible plant species	No. of informants citing the species	Total citations	No. of parts used	UVfo.
<i>Amaranthus dubius</i>	82	542	2	6.6
<i>Dioscorea schimperiana</i>	73	446	1	6.1
<i>Moringa stenopetala</i>	94	705	1	7.5
<i>Psophocarpus grandiflorus</i>	110	1034	2	9.4
<i>Solanum nigrum</i>	102	898	2	8.8

N.B. UVfo= Food use value

4. 10. Other use diversities of all collected plant species from the study area

- The whole plant species have their own uses in the ecosystem.
- These uses include being:
 - ✓ forage for livestock;
 - ✓ sources of materials,;
 - ✓ sources of fuel wood;
 - ✓ useful for social services;
 - ✓ provider of environmental services and ;
 - ✓ poison.

CHAPTER FIVE

5. DISCUSSION, CONCLUSION, AND RECOMMENDATIONS

5.1. Discussion

- ✓ The study area is rich in species composition (344 plant species belonging to 227 genera and 81 families were collected);
- ✓ Fabaceae was the most dominant with 41 species;
- ✓ This result agrees with the findings of Mirutse Giday and Gobena Ameni, 2003; Tesfaye Hailemariam *et al.*, 2009; Anteneh Belayneh *et al.*, 2012;
- ✓ This could be due to the fact that Fabaceae, Asteraceae, and Lamiaceae are among the largest dicotyledonous families in the Ethiopian flora (Thulin, 1989; Mesfin Tadesse, 2004; Ryding, 2006).

Cont.

- Fabaceae is a family of great economic importance containing besides the pulse crops many species used for:
 - ✓ forage, pasture improvement, charcoal production;
 - ✓ timber, gums, medicine, and ornament;
 - ✓ most of them fix atmospheric nitrogen to improve soil fertility due their associations with symbiotic bacteria (Thulin, 1989) .

Cont.

- ✓ In their growth forms the highest proportion was occupied with shrubs (34.2%);
- ✓ This finding is in line with the reports of Mirutse Giday and Gobena Ameni, 2003;
- ✓ This might be due to bush encroachment and cutting large/big trees for timber, construction and other purposes;
- ✓ The study area encompasses some flowering plant species that are endemic to Ethiopia.

Cont.

- ✓ 13 (3.8%) endemic plant species, some of which are in the IUCN Red Data List, were identified;
- ✓ This is in line with the typical feature of the Somalia - Masai regional centre of endemism which encompasses the study area (eastern and southern Ethiopia - except the mountains) (White, 1983).
- ✓ This centre of endemism encompasses about 1250 endemic plant species even if they are under great threat especially due to;
 - overgrazing with highly increased population of livestock of pastoralists.

Cont.

- ✓ The study area is a pool of large number of traditional medicinal plant species (127 spp.);

Table 38. Comparison of species richness among different woodland vegetation in Ethiopia

No.	Woodland vegetation in Ethiopia	Number of spp.	Authors	Rank
1	Borana Woodlands Vegetation	327	Gemedo Dalle <i>et al.</i> , 2005	2 nd
2	Dello Menna Woodland Vegetation	171	Motuma Didita <i>et al.</i> , 2010	6 th
3	Gamo Gofa Woodlands Vegetation	216	Teshome Soromessa <i>et al.</i> , 2004	3 rd
4	Nechisar Woodland Vegetation	208	Samson Shimelis <i>et al.</i> , 2016	4 th
5	Sire Beggo Woodland Vegetation	185	Abiyot Dibaba <i>et al.</i> , 2014	5 th
6	The present study area	344		1 st

Cont.

- The difference in species composition among places (vegetations) to be compared could be due to:
 - ✓ topographic differences;
 - ✓ environmental heterogeneity;
 - ✓ regeneration success;
 - ✓ competition in the respective vegetation;
 - ✓ climatic factors and;
 - ✓ level of exploitation (Chen *et al.*, 2003).

5.1.2. Plant communities in the vegetation of study area

- Plant communities are conceived as types of vegetation recognized by their floristic composition;
- It is common to use the dominant species in naming plant communities;
- Four different plant communities were identified in this study;
- Community **three** (*Boscia mossambicensis* - *Lannea schimperi* community type) is the **first in species richness** (with 164 species);

Cont.

- The presence of *Juniperus procera*, *Olea europaea* subsp. *cuspidata*, and *Podocarpus falcatus* in communities **two** and **four** indicated sufficient presence of characteristic species of dry afro-montane vegetation in the study area in the altitudinal ranges of 1800-3000 m a.s.l.
- But these species have been subjected to anthropogenic pressure (due to their multipurpose role) as proved by a number of stumps of the species observed in the vegetation.

Cont.

- The distinction in vegetation prototype among communities could be due to:
 - ✓ Differences in environmental gradients such as elevation, soil heterogeneity;
 - ✓ Microclimate, biotic responses to these gradients and;
 - ✓ Human-induced or environmental disturbances in a region (Urban *et al.*, 2000).

Cont.

- The observed community structure in the study area vegetation can be explained by:
 - ✓ differences in altitudinal ranges that were appropriate to the identified communities and;
 - ✓ habitat disturbances.
- Altitudinal gradients involve different interacting ecological factors which influence:
 - ✓ growth, development, diversity and;
 - ✓ distribution pattern of plants among plant communities in an area (Austin *et al.*, 1996).

Cont.

- In the same way, **human - induced disturbances** to fulfill different requirements has its own impact on variation among the identified communities.
- There was no plot that becomes ungrouped in the communities.

5.1.3. Similarity among plant communities

- Communities 2 and 3 showed the highest similarity ratio;
- The least similarity was exhibited between communities 1 and 4;
- This could be associated to slope, aspect, anthropogenic and other natural factors.

Cont.

- Species **richness** and species **evenness** together constitute its diversity;
- Species diversity for the total community in the study area was **relatively very high** ($H' = 4.87$);
- The **higher** the **value of H'** , the more diverse the quadrats or communities and;
- The Shannon index increase as both the richness and evenness of the community's increases.
- Species **richness is a measure** of the **total number of species** in a community;

Cont.

- In community wise comparison both species **richness** and **diversity** was the highest in community **three** (164 species and $H' = 4.69$ respectively) - Table 9;
- This could be due to **altitudinal factors** because lowlands (drylands) are commonly rich in species diversity (some of the quadrats in this community were **laid below 1500 m a.s.l.**);
- The **highest species evenness** was seen in **community one** although the second fewer species were recorded in this community ($J = 0.64$);

Cont.

- Community type 4 exhibited the least species richness and diversity (65 species and $H' = 3.63$ respectively) - Table 8;
- This could be due to anthropogenic impacts such as selective removal of important trees species for different purposes;
- For example, many big trees were seen cut down for their timber product in the forest in community 4.

Cont.



Figures A – C shows selective removal of important tree species for different purposes in the study area (Dugda Dawa District)

5.1.4. Structure of the vegetation

5.1.4.1. Tree and shrub density

- Grubb *et al.*, (1963) stated that the proportion described as a/b , is taken as the measure of size class distribution of vegetation;
- The District's vegetation showed relatively high woody species density (1,038 individuals ha⁻¹) when compared to some other dry afro-montane forests such as;
 - Denkoro dry afro-montane forest (526 individuals ha⁻¹) (Abate Ayalew *et al.*, 2006);
 - Nechisar (NNP) woodland vegetation (886.78 individuals ha⁻¹) (Samson Shimelse *et al.*, 2010))

Cont.

- Variations in density distributions can be attributed to variations in habitat preferences of species forming the forest, topographic gradients and the degree of anthropogenic influences (Whittaker *et al.* 2003).
- Accordingly, the proportion of individuals with DBH between 10 and 20 cm (a) to DBH > 20 cm (b) was 2.01 for Dugda Dawa District vegetation.
- This indicates that the proportion of medium-sized individuals (DBH between 10 and 20 cm) is greater than the large sized individuals

Cont.

- The proportion of small-sized individual (DBH < 10 cm) was much larger (53.9%) although the above ratio is lower;
- This indicate that Dugda Dawa District vegetation is dominated by smaller shrubs.
- Grubb *et al.*, 1963 stated that indicators of a predominance of small-sized individuals that starts to grow following excessive cuttings or other anthropogenic disturbances.

5.1.4.2. Size class distributions

- Decrease in the 5th and 6th height classes (25 - 29 m and > 29 m);
- Increase in the height classes 2nd and 3rd (10 - 14 m and 15 – 19 m);).
- This could be attributed to irregular recruitment which may be due to selective cutting of bigger size;
- 91.2% of the individuals have DBH less than 23 cm (DBH class 1 - 4);
- 8.8% of the individuals have DBH greater than 22 cm (DBH classes 5 - 9); and
- Only 4.9% of the total individuals have DBH greater than 42 cm;
- This indicate the dominance of small-sized individuals in the vegetation.

5.1.4.3. Basal area

- Consistent with Cain and Castro (1959) the results of **basal area analysis** are used to measure the **relative dominance** of woody species in a forest.
- In this study species such as *Podocarpus falcatus*, *Syzygium guineense* var. *guineense* and *Psydrax schimperiana* were identified to be more dominant than others.
- Even though about 42% of all the individuals had DBH less than 8 cm, the percentage contribution of these classes to the total basal area was only 1.25%.

Cont.

- Individuals in the DBH classes greater than 42 cm contributed to about 33.08% of the total basal area even though their density was about 4.9% of the total.
- The total basal area calculated for Dugda Dawa District vegetation was 90.37 m²/ha, of which more than 33% (29.9 m²/ha) was contributed by *Podocarpus falcatus*.
- The basal area of Dugda Dawa District vegetation is compared with the basal area of 10 other dry montane forests and woodland vegetation in Ethiopia.

- Table 44. Comparison of Dugda Dawa District vegetation with other 10 dry montane forests and woodland vegetations in Ethiopia with respect to basal area per hectare
- (Note: Ag = Angada, Cl = Chilimo, Dk = Denkoro, Dd = Dindin, DDD = Dugda Dawa District, Gd = Gedo, Ms = Menagesha, Mt = Metema, Ns= Nechisar, SB = Sire Beggo, WW= Wof - Washa vegetations)

Vegetation	Ag	Cl	Dk	Dd	DDD	Gd	Ms	Mt	Ns	SB	WW
Basal area/ha	80	30	45	49	90	36	36	43	50	19	102

5.1.4.4. Density, frequency and dominance

- *Olea europaea* subsp. *cuspidata*, *Podocarpus falcatus*, *Combretum molle*, and *Acokanthera schimperi* were the four most abundant species and constitute about 28.02% of the total density.
- This could be due to their relatively good regeneration capacity under shaded conditions in dry environments (Rey *et al.*, 2000).
- *Olea europaea* subsp. *cuspidata*, *Croton macrostachyus*, *Acokanthera schimperi* and *Combretum molle* were the most frequently occurring species.

- High frequency of a species always depends on factors which relate to habitat preferences, adaptation, degree of exploitation and availability of suitable conditions for regeneration (Rey *et al.*, 2000).

5.1.4.5. Importance value index

- Those species which receive lower IVI values need high conservation efforts while those with higher IVI values need monitoring management.
- The IVI results confirmed that *Podocarpus falcatus* and *Olea europaea* subsp. *cuspidata* were the most important species in the study area

- This may be due to their high dominance and density since they were found in relatively protected area.

5.1.4.6. Dominant species of the vegetation of Dugda Dawa District

- Species having IVI value above 5.00 are referred to as dominant because of the relative ecological importance they played in the vegetation and also their abundance in distribution, and high basal area within the vegetation.
- Species such as *Podocarpus falcatus*, *Olea europaea* subsp. *cuspidata* and *Croton macrostachyus* were identified as dominant species of the vegetation (Table 12)

5.1.4.7. Population structure

- Plant population structures help to understand population dynamics and regeneration status of species in a forest (Popma *et al.*, 1988).
- In this study four representative tree species were taken to see plant population structures and the ff four general patterns were seen:
 - a) Bell-shaped distribution formed by species with high number of individuals in the middle DBH classes; e.g. Species such as *Celtis africana* and *Croton macrostachyus*.
 - b) Positively skewed distribution (inverted J-curve); highest density in the lower DBH with gradual decrease in density towards the bigger sizes, which suggested good reproduction and healthy regeneration potential in the vegetation; e.g. Species such as *Nuxia congesta*, *Olea europaea* subsp. *cuspidata*, *Psydrax schimperiana*.

- c) Species having irregular distribution over diameter classes (Gauss-type distribution pattern). Some diameter classes were poorly represented indicating selective removal of specific sized individuals while other diameter classes are well represented; e.g. Species such as *Cassipourea malosana*, *Fagaropsis angolensis*, *Faurea speciosa*.
- d) U-shaped curve formed by species with little or no representatives in the middle DBH classes and represented only by the lower and higher DBH classes; e.g. Species such as *Podocarpus falcatus*, *Syzygium guineense* var. *guineense*.

5.1.4.8. Regeneration status of Dugda Dawa District's vegetation

- Almost all species did not have the expected amount of seedlings and saplings.
- Possible reasons for insufficient seedling and sapling for these selected tree species in the vegetation might be:
 - grazing and browsing (disturbance) effect;
 - lack of safe site for seed recruitment;
 - nature of seeds of certain trees which seek dormancy period;
 - seed predation;
 - litter accumulation,;
 - Pathogens;
 - species specificity; and
 - moisture stress or probably they might have other alternative adaptations for propagation and reproduction rather than seed germination.

5.1.4.9. Phytogeographic comparison

- Dugda Dawa District vegetation shared significant number of species with Sire Beggo woodland vegetation (Abiyot Dibaba *et al.*, 2014) with Sorensen's coefficient of similarity value of 0.31.
- The high similarity observed among these vegetations formations could be due to similar altitudinal ranges and climatic conditions.

5.1.5. Traditional medicinal plants in the study area

- The term medicinal plants include various types of plants used in herbalism or traditional medication.
- Besides that these plants play a critical role in the development of human cultures.

5.1.5. 1. Taxonomic diversity of medicinal plants in the study area

- Considerable amount of medicinal plants species (127 species) were found in Dugda Dawa District vegetation which is in line with the overall observed species diversity in the study area.
- Of the 127 species, 81 species (64.6%) were cited for their uses to treat human ailments whereas 24 species (18.9%) were reported for treating livestock ailments and 22 species (16.5%) for their therapeutic uses against various ailments affecting both humans and livestock

Cont.

- Fabaceae was with the highest number of medicinal plant species (13 species) followed by Asteraceae (9 species) and Lamiaceae (9 species).
- This could be due to the abundance of species of Fabaceae, Asteraceae and Lamiaceae in the Ethiopian flora (Thulin, 1989; Mesfin Tadesse, 2004; Ryding, 2006).
- The number of medicinal plants harvested in the district was found to be relatively higher than that of some other areas in the country investigated for their traditional health care in humans and livestock such as Getaneh Gebeyehu *et al.*, (2014) 107 species; species; Tadesse Beyene, (2015) 121 species.

Cont.

- Cultural and way of life factors might have been the most important reasons in using such large number of medicinal plants maintained as a highly valued inheritance of the local people.
- In addition economic, ease of accessibility and effectiveness related factors might have played major roles for Dugda Dawa District people to rely on traditional medicine.
- Being dominant of medicinal plant species of the families Fabaceae, Asteraceae, and Lamiaceae could be attributed to their wider distribution and plenty in the flora area.

5.1.5. 2. Distribution of medicinal plant species across plant communities

- Traditional medicinal plants were found distributed in each of the identified plant community types in the vegetation.
- Community 1 (*Nuxia oppositifolia* - *Calpurnia aurea* community type) contained 39 different traditional medicinal plant species.
- Examples; *Calpurnia aurea*, *Maesa lanceolata*, *Millettia ferruginea* and *Prunus africana*

Cont.

- A total of 58 medicinal plant species were found in community 2 (*Faurea speciosa* - *Terminalia schimperiana* community type).
- Some of the major medicinal plants in this community type were *Albizia schimperiana*, *Canthium lactescens*, *Dodonea angustifolia*.
- Community type 3 (*Boscia mossambicensis* - *Lannea schimperi* community type) was found to be the richest in medicinal plant composition in that it contained 61 species of traditionally used remedial plants.

Example; *Asparagus flagellaris*, *Balanites aegyptiaca*, and *Capparis tomentosa*.

Con.

- Community 4 (*Margaritaria discoidea* - *Maytenus undata* community type) was found to contain a total of 32 medicinal plant species.
- Some of the most-cited medicinal plant species available in this community type include *Acokanthera schimperi*, *Clusia lanceolata*, *Dioscorea schimperiana* and *Ekebergia capensis*.
- The highest value of medicinal species richness (61) was recorded for community three and medicinal species diversity (Shannon's diversity) ($H' = 3.79$) and medicinal species evenness ($J = 0.52$) were both highest for community two.
- This could be due to the difference in the preference of habitat by these medicinal plants.

5.1.6. Medicinal plants used to treat only human ailments

5.1.6.1. Diversity of reported medicinal plants used for human ailments

- A total of 81 medicinal plant species belonging to 77 genera and 51 families (48 angiosperms, one gymnosperm, and two bryophytes) were reported to be used for treating human ailments.
- Family Fabaceae was represented by the highest number of species (10 species, 7.9%), followed by Lamiaceae (seven 5.5%).

Cont.

- Utilization of such a large number of medicinal plants by people in the study area may indicate that the majority of the people continue to employ indigenous medicinal practices to date.
- Four of the medicinal plants which are used to treat human ailments were endemic to Ethiopia.
- Identified growth forms of medicinal plants indicated that shrubs (30; 37%) were more dominant.
- This could be due to the dominant occurrence and impact tolerance capacity of shrubs in the study area.

Cont.

- The majority of medicinal plants (74 species) were obtained from the wild.
- But, the wild habitats are highly depleted due to an increased human and livestock population which will result in the loss of many medicinal species.

5.1.6. 2. Parts of medicinal plants used for remedy preparation

- About 36.6% of the preparations for treating human ailments were obtained from leaves.
- The higher usage of leaves in traditional remedy preparations could partly be due to its easy availability.

Cont.

- Most of the remedy preparation (93.7%) was reported from freshly collected plant parts.
- This could be due to the belief that this form could attain high efficacy since it could contain higher bioactive ingredients (curative elements, a knowledge which could be obtained from long and repeated experience).

5.1.6. 3. Types of disease, medicine preparations and treatment methods

- Forty nine disease types, affecting humans, were identified to be treated with traditional medicines.

Cont.

- Gastro - intestinal diseases were the most frequently reported human ailments.
- These diseases were diagnosed commonly through interview and visual inspection of the patients' before any herbal medicine administration.
- The major mode of herbal medicine preparation for human ailments were chopping or pounding and homogenizing plant parts (35.6%).
- Oral application was the most common route of administration (162 preparations, 70.1%).

Cont.

- Determination of remedies dose for various ailments was based on physical appearance, age, and gender of the patient (no standardized measurements).
- Remedies were reported to be measured in coffee cups, water glasses, liters while others were measured with tip of fingers or pieces of particles.
- Milk, yoghurt, honey, and coffee were mentioned as antidotes for traditional medicines with adverse side effects such as vomiting, diarrhoea, and feeling of burning and sometimes weakening of the patient.

Cont.

- Patients with gastro - intestinal problems, venereal diseases, malaria, hepatitis, hypertension, diabetics, TB, rabies, poisons, etc were commonly reported to be treated with liquid preparations or chewable plant parts given orally.
- Culture, efficacy, availability, and economic factors were reported as the key factors which lead the community to use traditional medicines other than modern healthcare systems with their unaffordable high prices and unavailability.

5.1.6. 4. Marketability of medicinal plants

- In the culture of Guji Oromo (ethnic group of the study area) it is forbidden to sell traditional medicine in the market.
- When traditional healers cure a patient they will be given certain amount of dried and pounded tobacco, coffee with salt or sugar and if it is critical disease a goat or heifer not money as the cultural rule permits (in kind form of payment).
- Sometimes the cured person returns the favor through inviting the healer and his family overnight in his house.

Cont.

- But some traditional medicinal plants can be sold for other purposes such as:
- *Coffea arabica* and *Rhamnus prinoides* to be used in the preparation of drinks;
 - *Ruta chalepensis* to be used as spice in milk preparation;
 - *Combretum molle*, *Olea europaea* subsp. *cuspidata* and *Osyris quadripartita* for fumigation in producing good odor and feeling for the body and house.

5.1. 6. 5. The most preferred plants for treating human ailments

- The output of preference ranking exercise on medicinal plants that were reported to be used against tooth ache showed that *Zanthoxylum chalybeum* is the most preferred species to treat the reported disease followed by *Scherebra alata* and *Carissa spinarum*.
- This indicates that indigenous people of the study area have sufficient knowledge on the healing potential of medicinal plants for different diseases.

5.1.6. 6. Identification of multipurpose medicinal plants for their conservation priority

- Direct matrix ranking exercise for ten selected multipurpose medicinal plants in five use diversities (charcoal, construction, furniture and tools, firewood and medicinal) indicated that:
 - *Warburgia ugandensis* was ranked first (most - threatened);
 - Followed by *Olea europaea* subsp. *cuspidata* and *Fagaropsis angolensis*.
- Since stem bark of *Warburgia ugandensis* is highly and unwisely used in treating different diseases in Guji Oromo traditional medication its population is reaching nearly zero (lost through drying).

5.1.6.7. Effectiveness of medicinal plants

- Among the twelve categorized human ailments the highest informant consensus factor values (ICF values) was for musculoskeletal and nervous system diseases.
- High ICF values are important to name plants of particular interest in the search for bioactive compounds (Heinrich *et al.*, 1998).
- The highest plant use citation was seen for gastrointestinal diseases.

5.1.6.8. Relative healing potential of medicinal plants used for treating human ailments

- The highest fidelity level value (97%) was recorded for *Ocimum urticifolium* followed by *Withania somnifera* (96%).
- The highest fidelity level value record for *Ocimum lamiifolium* was obtained under the febrile therapeutic category;
- For that of *Withania somnifera* was found in the evil spirit disease category.

Cont.

- In this study, ICF values were used to identify the harmony of the informants on the reported cure for the group of ailments (musculoskeletal and nervous system diseases) of the plant; while
- FL computes the significance of a species (*Ocimum urticifolium*) to treat a given disease (febrile diseases).
- Hence, their analyses values become different; high for fidelity level than ICF.

5.1.6. 9. Use diversity of medicinal plants used for humans

- Results showed that all the 81 medicinal plant species recorded for human ailments treatment in the district were cited for one or more uses other than their medicinal role such as useful for:
- environmental services such as erosion control, soil improvement (all spp.);
 - being food and shelter for wild animals (majority);
 - balancing climatic conditions and this is the general truth with no compromise (all spp.);
 - fuel (charcoal and fire wood) for the local people (44 spp.)

Cont.

- fodder indicating their supplementary role in supporting the livestock wealth of the district (39 spp.)
 - construction and material making (25 spp.);
 - as wild edible plants (22 spp.);
 - social services (4 spp.); and
 - being poisonous (2 spp.).
- These results indicated how much the indigenous knowledge of the local people is used in using plant resources for different purposes to ensure their existence through fulfilling their requirements.

5.1.7. Ethnoveterinary medicinal plants

5.1.7. 1. Medicinal plant diversity used only for ethnoveterinary in Dugda Dawa District

- The reported ethnoveterinary medicinal plants (24 species belonging to 24 genera and 17 families) showed that the study area is relatively rich in ethnoveterinary medicinal plants diversity and indigenous knowledge related with each traditionally used species.
- Four species (16.7%) was recorded for Asteraceae, followed by Acanthaceae, Anacardiaceae, Lamiaceae, and Vitaceae (two species, about 8.3% each).

Cont.

- About 8.3% (two species) of the ethnoveterinary medicinal plants of Dugda Dawa District were endemic to Ethiopia.
- There were more climbers (eight species, 33.3%), followed by shrubs and herbs (five species, 20.8% each).
- All the documented ethnoveterinary plant species were harvested from the wild.
- Overgrazing, deforestation, charcoal making, and firewood collection were claimed as major factors affecting the ethnoveterinary plant species of the study area.

5.1.7.2. Specification of livestock ailments, number, and part of plant species used

- The majority of the reported medicinal plant species (21 species or 87.5%) were found to be applied to treat one or more of the fourteen different **cattle ailments**.
- The majority of ethnoveterinary medications (95.8%) were reported to comprise medicinal parts of a single medicinal plant.
- Amongst all plants reported, the highest proportion of species was claimed to treat breathing problem (28.6%).

Cont.

- The highest number of multiple ethnoveterinary uses was recorded for *Prunus africana* and *Viscum congolense* (each used against three ailment types).
- Leaves were the most widely used plant parts (44.1%) for ethnoveterinary medicine preparations followed by barks (14.7%) in the study area.
- Almost all remedies were prepared from freshly harvested plant parts.
- As reported by informants, from their long experience high efficacy is attained from freshly collected plant parts since they contain much active ingredients in the form of secondary metabolites.

Cont.

- Breathing system diseases were the most prevalent animal health problems reported in the study area.
- *Clematis simensis*, *Viscum congolense*, and *Lannea rivae* were ethnoveterinary medicinal plants identified and the most preferred species to treat breathing system diseases.

5.1.7. 3. Livestock ailments, remedy preparation, routes of administration and dosages

- A total of 35 veterinary ailment types were identified in the study area.
- Most of (34.3%, twelve ailment types) the veterinary ailments belong to the breathing system disease category, followed by gastro - intestinal diseases (22.9%, eight diseases).

Cont.

- Healers treat veterinary ailments based on observation of the animals or evidence obtained by asking the livestock owners.
- Medicines are commonly given only after the diseased animal is visually examined by a traditional healer for any symptom on its suspected body part.
- Pounding/chopping/crushing the remedial part and making its solution with cold water was found to be the major method of local remedy preparation (93.1%).
- Oral administration of traditional medicines was reported as the main treatment method for most diseases (20 preparations, 66.7%).

Cont.

- Some traditional practitioners reported use of coffee cup, water glasses and bottles to determine dosage for some traditional medicines;
- Others reported to use their finger tip or full of a small dish unprocessed parts to treat ailments (no standardized doses).
- The highest plant use citation (30%) was recorded in the present study for breathing system diseases with ICF value of 0.90.
- *Cyphostemma serpens* was identified as having the highest healing potential (97%) in treating black leg, hepatitis, and FMD.

5.1.7. 4. Use diversity of medicinal plants used for livestock

- With direct matrix ranking exercise made among five ethnoveterinary medicinal plant species to identify those having multipurpose, *Prunus africana* was ranked first (most - threatened) followed by *Syzygium guineense* var. *guineense* and *Combretum collinum*.
- These multipurpose medicinal plant species were exploited more for firewood, construction, and charcoal purposes than for their medicinal uses

Cont.

- Out of the 24 different medicinal plant species used for livestock ailments treatment, the highest medicinal use values (UVmed) were recorded for *Lannea rivae* (8.0).

5.1.8. Ethnobotanical knowledge of medicinal plants used for both humans and livestock in Dugda Dawa District

5.1.8.1. Diversity of medicinal plants used

- One of the alternatives for the solution of health problem rises in a large segment of rural population and their livestock is employing traditional medicine in general and medicinal plants in particular.

Cont.

- 22 medicinal plant species belonging to 20 genera and 14 families which are used to treat both humans and livestock ailments were recorded.
- The highest number of species was recorded for the families Euphorbiaceae, Rubiaceae and Rutaceae (three species each, 13.6%).
- Regarding the growth forms, there were more shrubs (ten species, 45.5%).
- About 90.9% (20 species) of the documented common medicinal plant species were harvested from the wild.

5.1.8. 2. Ailments treated with medicinal plants used for both humans and livestock

- 33 human and 27 veterinary ailment types were identified for which informants reported to use one or more medicinal plant species to treat them.
- Most of (seven ailment types, 21.2%, in humans and six ailment types, 22.2%, in livestock) the ailments belong to the gastro - intestinal and internal parasite disease category.
- Diarrhea and tooth ache diseases in humans and coughing in livestock were found to be the most commonly reported forms of ailments in the district.

Cont.

- Chewing medicinal parts and/or applying pounded remedies on the infected tooth and oral administration of homogenized herbal preparations for diarrhea and coughing were reported as the main treatment methods.

5.1.8. 3. Composition of remedies for both humans and livestock

- The majority of human and livestock medications (78.3%) were reported to comprise medicinal parts of a single medicinal species.
- Amongst all plants reported, the highest proportion of species was claimed to treat tooth ache and diarrhea/stomach ache (40.9%, nine species each).

Cont.

- The highest number of multiple ethnoveterinary uses was recorded for *Croton macrostachyus* (used against 13 ailment types).

5.1.8.4. Medicinal plant parts used for remedy preparation

- Most (30.2%) of the preparations was found to be from leaves alone.
- This might be due to their consistent supply of fresh metabolites.
- Of the remedies 92.1% were prepared from freshly harvested plant parts, whereas 7.9% were from dried forms.

5.1.8.5. Mode of remedy preparation, routes of administration and dosages

- Pounding the remedial part and homogenizing it with cold water was found to be the major mode of remedy preparation (58.2%).
- Oral administration was the most cited route of administration (67 preparations, 77 %), followed by dermal (15 preparations, 17.2%).
- Physical observation and information from the patient or owner of diseased animal are used to determine preparation doses to treat both humans and livestock ailments.

Cont.

- With preference ranking exercise *Vangueria apiculata* and *Croton macrostachyus* were the most preferred species from five medicinal plants that were reported to be used against hepatitis in both humans and livestock to treat the reported diseases.
- Direct matrix ranking exercise made on five selected multipurpose medicinal plant species revealed that *Calpurnia aurea* was ranked first (most threatened) followed by *Balanites aegyptiaca*.

Cont.

- In computation of ICF the highest values for six main ailment categories which are common to humans and livestock was recorded for gastro - intestinal and internal parasites (0.83).
- The highest plant use citation (27.7%) was recorded for gastro - intestinal and internal parasites.
- *Solanum dennekense* showed the highest fidelity level value (93%) for tissue cancer and cold disease category.
- Of the 22 different medicinal plant species, the highest medicinal use values (UVmed) were recorded for *Croton macrostachyus* (9.2).

Cont.

- Water served as ‘solvent’ almost in all ethno formulations of traditional medicines whenever dilution is required.
- Different additives are incorporated in 23.4% of the whole ethno formulations.
- Certain additives are frequently used to improve the suitability of some remedies that are taken orally either through reducing their bitterness and bad flavor or increasing their efficacy.
- The highest usage of additive was reported for magado salt (locally produced salt) (42.1%).

5.1.8. 6. Distribution of indigenous knowledge on medicinal plants among different social groups in the community of the study area

- While more medicinal plants were reported by men than women, the difference was not significant ($P > 0.05$) when the average number of medicinal plants mentioned by each group was compared.
- There was a significant difference ($P = 0.00$) in the number of medicinal plants reported by senior members of the community (> 39 years old) and young- to middle-aged members (< 40 years old) - more number of medicinal plants was reported by elders than by youngsters.

Cont.

➤ This could be due to:

- their high degree of opportunity for more cultural contact and experience with plants and associated therapeutic uses than that of younger people; or
- due to the absence of sharing indigenous knowledge freely because of its secrecy; and
- if it presents being along the preferred male line of the family of the ethnic group of the study area.

➤ Similarly significant differences were also seen in the number of medicinal plants reported by key informants and randomly taken informants, illiterate and literate informants.

Cont.

- More number of medicinal plants was reported by illiterates and key informants than literates and randomly taken informants.
- This could again be related to the impact of life long experience and serious secrecy in using medicinal plants in the former, and modernization in the latter case.
- Large number and types of humans and livestock diseases (82 and 62 disease types respectively) for which patients were visited by traditional healers indicated a preference of local people in the study area to use traditional medicines.

Cont.

- The reported reasons for this to happen were:
 - efficacy and availability of these medicines;
 - cultural trend, and life standard (being poor);
 - factors which forces the community to visit traditional healthcare practitioners than modern healthcare centers with unreasonable prices.

5.1. 9. Ethnobotanical study of wild edible plants in Dugda Dawa District

5.1.9.1. Taxonomic diversity of wild edible plants

- The study area is generally endowed with various and rich sources of wild edible plants (71 spp.) which serve the local communities as food sources and for other purposes.

Cont.

- Such a large number of wild edible plant species was not seen registered from a single district in the country.
- The 71 wild edible plant species belong to 52 genera and 37 families; and
- Concerning their growth forms, trees and shrubs contributed equal number of wild edible plant species (26 species each).
- Of all the families which yielded these wild edible plant species, the Fabaceae and Anacardiaceae were the most dominant with seven species (9.9% each)

5.1.9. 2. Distribution of wild edible plant species across plant communities in Dugda Dawa District vegetation

- Traditional wild edible plants were found distributed in each of the identified plant community types in the vegetation.
- Community 1 (*Nuxia oppositifolia* - *Calpurnia aurea* community type) contained 17 different wild edible plant species such as *Cordia africana*, *Ficus sur*, *Ficus vasta*, *Mimusops kummel*, *Rhus vulgaris* and *Syzygium guineense* var. *afromontanum*.
- A total of 28 wild edible plant species was found in community 2 (*Faurea speciosa* - *Terminalia schimperiana* community type) such as *Canthium lactescens*, *Cordia ellenbeckii* and *Physalis peruviana*.

Cont.

- Community type 3 (*Boscia mossambicensis* - *Lannea schimperi* community type) was found to be the richest in wild edible plants composition in that it contained 41 species such as *Amaranthus dubius*, *Balanites aegyptiaca*, *Balanites rotundifolia* and *Commiphora africana*.
- Community 4 (*Margaritaria discoidea* - *Maytenus undata* community type) was found to contain a total of 18 wild edible plant species such as *Acanthus eminens*, *Acokanthera schimperi*, *Dioscorea schimperiana* and *Flacourtia indica*.

Cont.

- Wild edible plant species richness, diversity (Shannon's diversity) and evenness values were recorded as 41 species, $H' = 3.22$ and $J = 0.47$ respectively for community three.
- But when we consider this condition in the whole vegetation of the study area, community three has the highest value in species richness (164 species) and species diversity ($H' = 4.69$) and community one is with the highest species evenness ($J = 0.64$).

5.1.9. 3. The role of wild edible plants in household food security and food use categories of the people of the study area

- The major challenge to household food security in the study area is climatic conditions disturbance.
- Very short and irregular rain happened for the past many years.
- This caused the subsistence agricultural activities to diminish and unsuccessful.
- The rural people in the study area hold more than enough indigenous knowledge about how and when to use wild edible plants.

Cont.

- These plants are important to household food security and dietary diversification in different rural areas to:
 - supplement the staple food;
 - fill the gap of seasonal food shortages; and
 - as emergency food during famine or during prolonged drought time or social unrest.
- Of the total wild edibles:
 - 7% of the species used during periods of ample food production to supplement the staple diet;
 - 78.9% of the species used to fill the gap of seasonal food shortage; and
 - 14.1% of the species used during famine.

5.1.9.4. Distribution of indigenous knowledge on wild edible plants among the different social group in the local community

Stped on pp.131

☐ Publications

▪ Articles published during the course of this PhD work are:

1. Mersha Ashagre Eshete, Zemedede Asfaw and Ensermu Kelbessa (2016). Ethnobotanical study of wild edible plants in Burji District, Segan Area Zone of Southern Nations, Nationalities and Peoples Region (SNNPR), Ethiopia. *Journal of Ethnobiology and Ethnomedicine* (2016) 12:32/ DOI: 10.1186/s13002-016-0103-1.
2. Mersha Ashagre Eshete, Zemedede Asfaw and Ensermu Kelbessa (2016). A review on taxonomic and use diversity of the family Amaranthaceae in Ethiopia. *Journal of Medicinal Plants Studies* 2016; 4(2): 185-194/ISSN 2320-3862.